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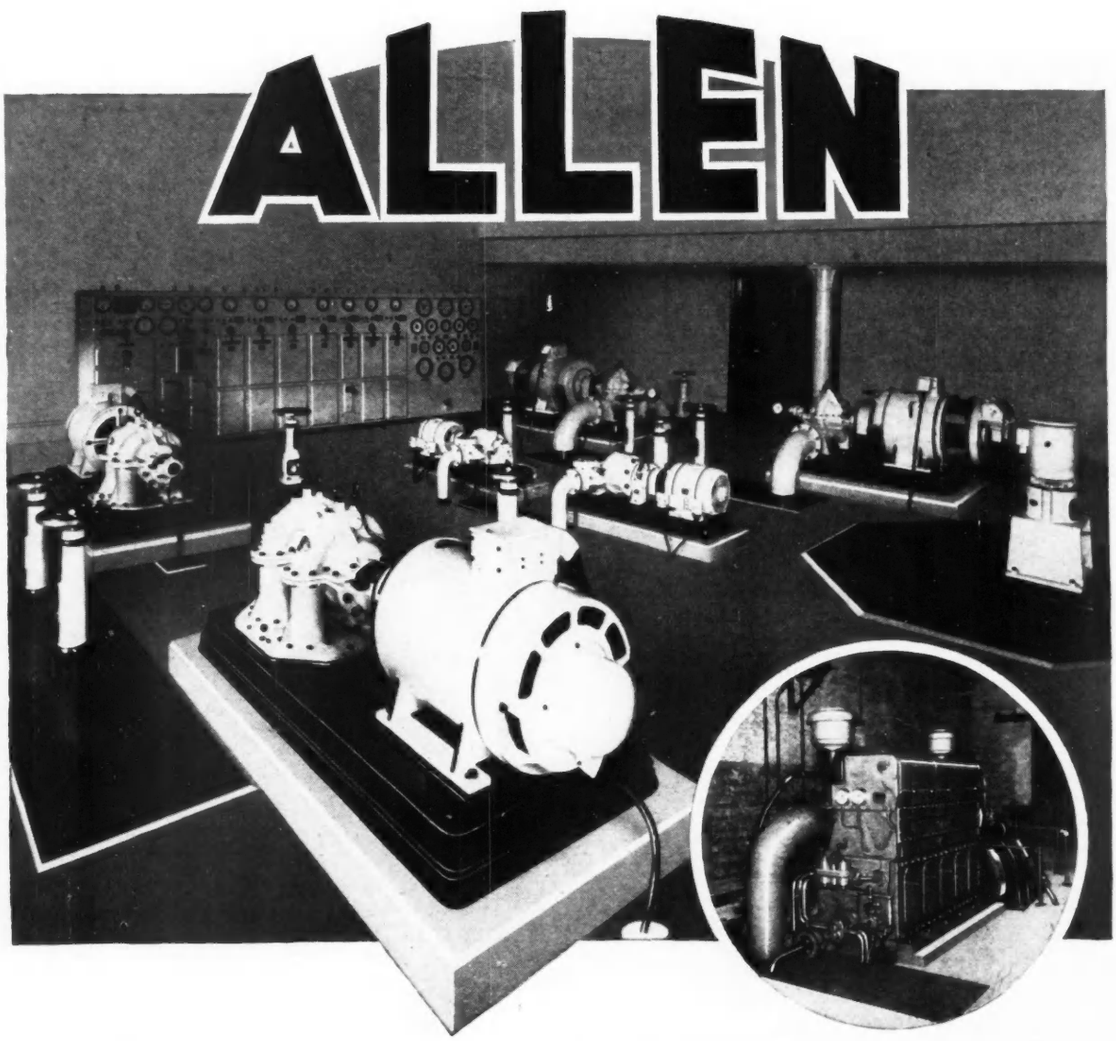

WATERWORKS PUMPING PLANT

THE illustration shows the interior of the Ravensthorpe Pumping Station of the Northampton Corporation. This installation of ALLEN motor-driven pumps, comprises :—

A vertical 2-stage turbine type well pump (125 g.p.m., 80 feet head) ; two single-stage double-suction pumps (in background) supplying low-pressure mains (1215 g.p.m., 167 feet head, 1750 r.p.m., or 695 g.p.m., 70 feet head, 1130 r.p.m.) or any intermediate duty obtainable over this range ; two 2-stage double-suction pumps (in foreground) serving high-pressure mains (1215 g.p.m., 175 feet head) ; two 4-stage pumps (in centre) for supplying rural districts (100 g.p.m., 400 feet head).

The electrical switchboard incorporates the metering panel, pressure gauges and recorders for the hydraulic system. In an adjacent building is a 150-kW Allen Diesel engine generating set for stand-by duty (inset picture).

This station which originally housed steam-driven plant, is a good example of how existing buildings can be used to accommodate machinery of entirely different character.

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ATTENUATION OF SOUND IN LINED AIR DUCTS.

By C. P. BRITTAIN, Grad.I.E.E., C. R. MAGUIRE, B.Sc., A.M.I.E.E., R. A. SCOTT, Ph.D., F.Inst.P., and A. J. KING, D.Sc., M.I.E.E., F.Inst.P.

(*Concluded from page* 98.)

To study the effect of corners it was necessary to construct a new duct which would permit one section to be swung round so as to make an angle (which could be varied) with the other section. The opportunity was taken to make the new duct less in height since, with the top and bottom totally reflecting, the axial attenuation should be independent of the height. Besides reducing the weight and cost of the apparatus and lining materials, the use of a shallow duct avoids the necessity for tedious exploration of vertical non-uniformities at each position along the duct. A height of 2 in. was decided on as a compromise between the conflicting considerations of making it small compared with a wavelength to avoid non-uniformities, and yet large compared with cracks at top and bottom of the material to be representative of the lining. The top and bottom of the duct were made of ½-in. thick steel plates and the sides of steel bars of the same thickness. The duct was constructed in three sections jointed together and called the initial, corner and terminal sections. The initial section was limited to a length of 4 ft. 5 in. by considerations of available space and the necessity for swinging it round. This unfortunately puts a lower limit to the frequencies which can be studied, since it is necessary to have at least a wavelength before the corner in order to interpret the results obtained. The corner section consists of four interchangeable pairs of plates and side pieces providing angles of 0, 30, 60 and 90 deg. The 0 deg. plates were included to permit a comparison with the previous work in the deeper brick duct. The terminal section could be made longer, as it does not swing round, and so consists of 7 ft. of steel duct similar to the initial section, supplemented by 6 ft. of wooden duct of the same air-passage dimensions but filled with cotton waste. The plates are drilled to permit assembly so as to give air passages of various widths and also to permit entry of a measuring probe tube. The latter is 0·136 in. in diameter and of 0·062 in. bore, and is connected through a short length of valve tubing to a suitably encased piezo-electric microphone. All holes in the duct, except that being used for the probe, are filled with copper plugs to give a flush surface inside. Thin cork gaskets provide good seals between the top and bottom plates and the side walls. The test tone is provided by a moving-coil diaphragm unit, coupled by a rubber hose pipe to an expanding mouth adjusted to suit the particular width of duct being tested. Fig. 8 shows the apparatus assembled as a 90-deg. corner. The superstructure over the duct is a runway to support the microphone on a rubber cord above the plugged holes for the probe tube. Fig. 9 is a closer view of the 90-deg. corner with the top plate removed. The porous lining material used was rock wool of 8·1 lb. per cubic foot density.

The attenuations of sounds of typical frequencies were studied along the straight sections before and after the corner with the technique previously described, except that vertical explorations were no longer necessary. Variations in sound pressure across the duct were encountered near the corner at high frequencies when the width of the air space exceeded a wavelength. These variations were not large, and it was found sufficient to take the mean of three readings spaced across the duct. Readings were taken with the 0 deg. coupling plates, that is, with the whole duct in a straight line, and agree well with those obtained earlier under corresponding conditions of lining and duct width in the larger brick duct. Advantage was taken of these readings in the long, straight, shallow duct when drawing mean lines through the points obtained for the two shorter sections of the bent duct before and after the corner. The attenuation due to the corner is then given by the vertical distance between these two mean lines. This is illustrated in Fig. 10 for the case of an 8-in. wide duct with 2-in. linings of rock wool, leaving a 4-in. wide air space. For the tone of 2,000 cycles per second, the mean lines before and after the 90-deg. corner have a slope of 14·4 db. per foot. The attenuation at the corner, given by the vertical separation of these lines, is 6 db. Readings such as this have been taken for 30-, 60- and 90-deg. corners with 1-in., 2-in. and 4-in. thick linings, 2-in., 4-in. and 8-in. wide air spaces, and at frequencies from 200 cycles to 5,000 cycles per second. The results are difficult to summarise owing to their wide variation with the conditions of test, but it is not thought worth while to give them in full owing to their limited field of application. Under certain conditions, particularly with wide air spaces, the curves of attenuation against frequency for the three angles show characteristic shapes and these are illustrated by Figs. 11 to 15, on page 146. With 2-in. air spaces, the curves of attenuation for all three thicknesses of lining and for the three angles do not exceed ±5 db. at any frequency and the average attenuation is of the order of 1 db to 2 db. It is interesting to note that, under certain conditions, the corner can render the sound absorbing system in the immediate vicinity less effective, corresponding to a negative attenuation. Large variations in performance with test conditions are apparent and it would be difficult to combine a succession of corners so as to provide a large attenuation over a wide frequency band. In designing such a succession of corners it would be necessary, of course, to consider aerodynamic losses, and from this point of view it is probable that angles of deviation not exceeding 45 deg. would be preferable to larger ones.

The investigation of the attenuation produced by resonant absorbers was carried out in the brick duct already described. This was used in preference to the shallow duct because, as the size of a panel is reduced, the effect of the constraint due to mounting becomes more important. On the other hand, it is necessary to discourage leakage of sound along the duct in the linings so, if hollow absorbers with little or no filling of porous material are used, it is advisable to subdivide the absorbers at intervals along the duct by vertical partitions. In addition to long absorbers, therefore, some were made as sheet-steel boxes, 19 in. by 6 in. by 3 in.

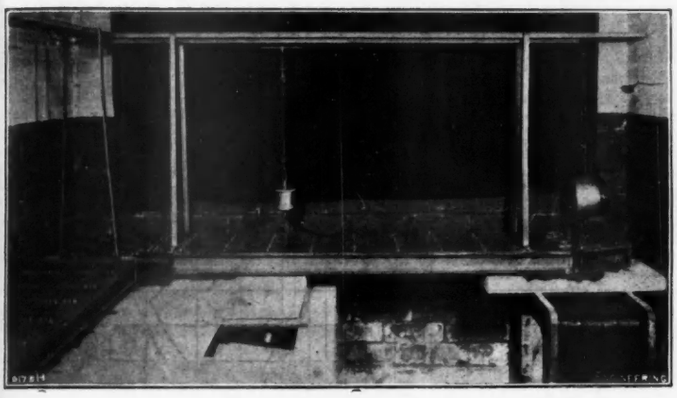


FIG. 8.

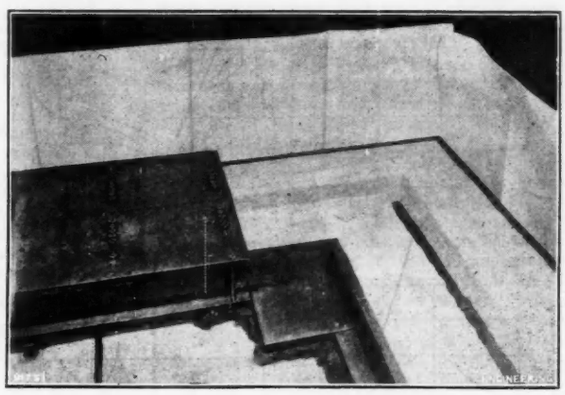
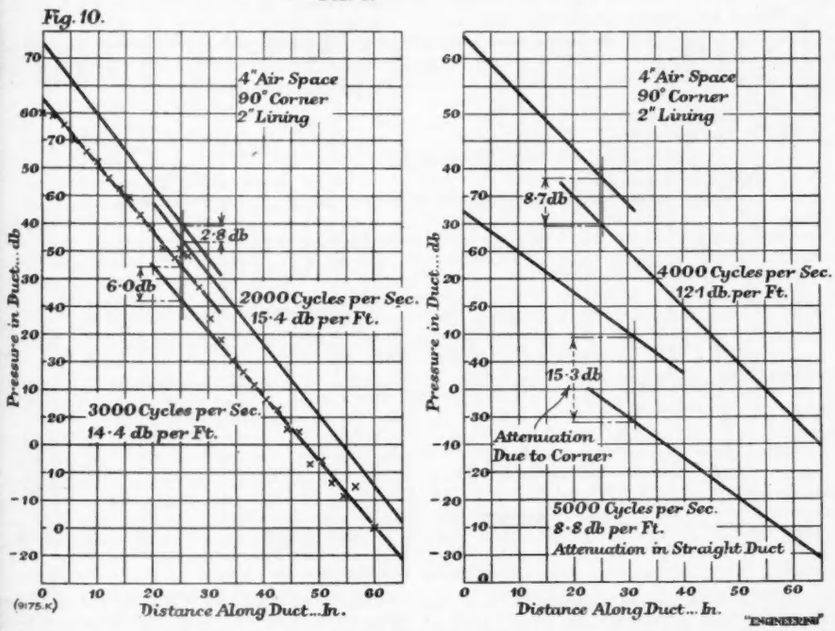
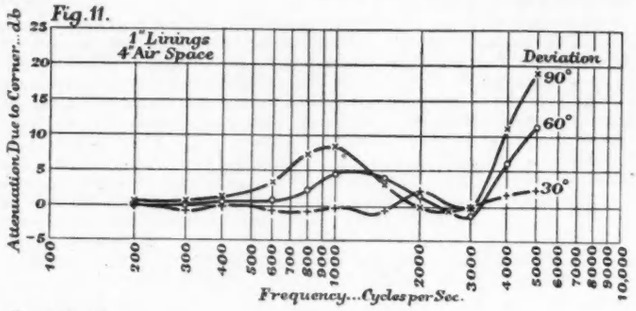


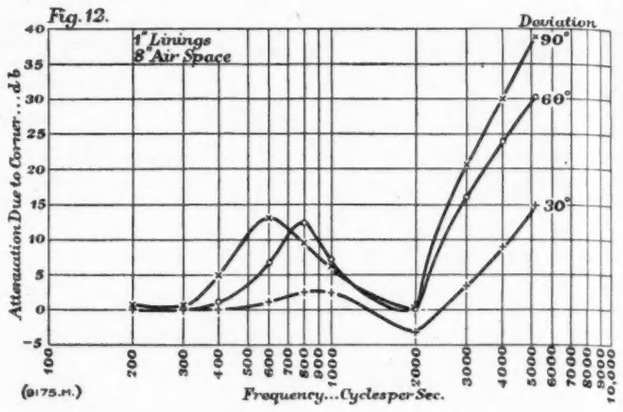
FIG. 9.

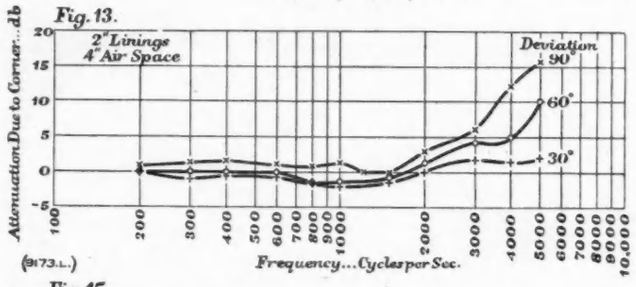
Fig. 10.

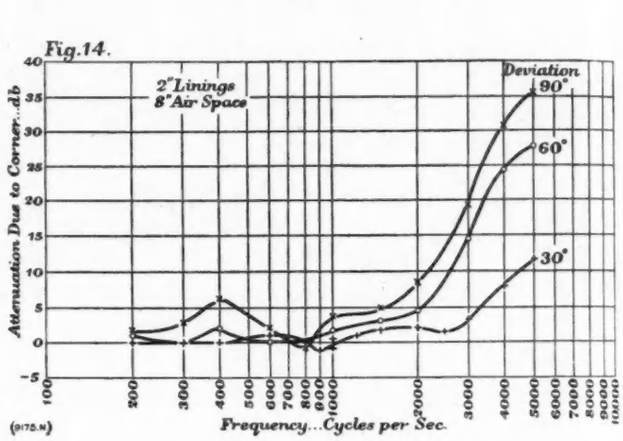


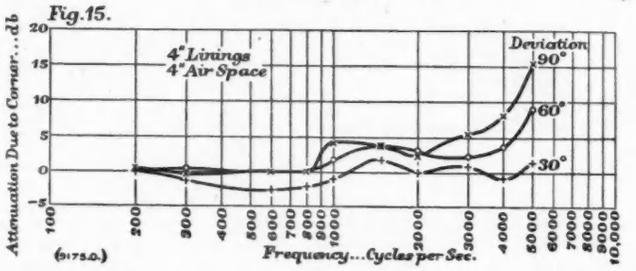
SOUND ATTENUATION IN AIR DUCTS.







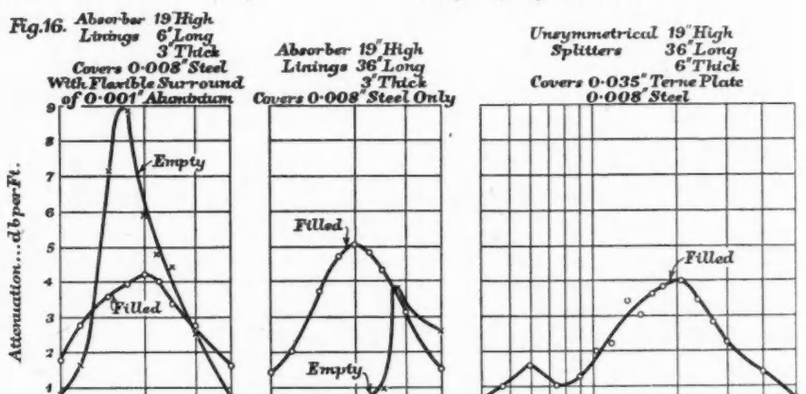




deep, each with a ¼-in. frame to take a sheet 19 in. by 6 in. or a panel 18 in. by 5 in., with flexible surround. Two dozen of these boxes were obtained to line both sides of a 6-ft. test length of duct, a 6-ft. length of the same cross-section being used as a preliminary duct and a 12-ft. length as a terminal duct to absorb the test tone as before. With hollow absorbers having little or no porous material inside, and of a thickness small compared with a quarter of a wavelength, the prediction of the resonant frequency where attenuation is expected to be a maximum is fairly simple provided the constraint at the edges can be neglected. This is the case for large flexible sheets and when a flexible surround is provided. If m is the mass in gm. of a sq. cm. of the panel, and d cm. is the depth of the air space behind the panel, the resonant frequency f_0 is given by

$$f_0 = \frac{190}{\sqrt{m\,d}} \text{ cycles per second.}$$

With the absorbers empty, the resonance is naturally sharp and the attenuation in a duct is correspondingly selective. Filling them with porous material introduces more damping, which flattens the resonance and broadens the attenuation-frequency curve. In addition to resistance, the porous material contributes some reactance to the system, so for accurate prediction of the resonant frequency of filled absorbers it is necessary to know the acoustic impedance of the filling. Some information on this has been given. Typical experimental results illustrating the above points are given in Fig. 16, which shows the sharp peaks of attenuation associated with empty absorbers and the broader curves produced by filling the absorbers with porous material. In these experiments the rock-wool filling had a nominal density of 10 lb. per cub. ft., and the air space was 6 in. in all cases. The smaller peak of the long empty absorbers is presumably due to increased transmission within them compared with the short boxes. It is apparent that this effect does not operate with



the absorbers filled, due, as discussed above, to the reduced transmission through the porous material in the absorbers. Fig. 16 also illustrates the use of unsymmetrical resonant absorbers as splitters. In these, the front and back panels are made resonant at different frequencies by choosing sheets of suitably different mass, and two or more of the units are arranged side by side in an air duct with dissimilar panels facing each other. When the two resonances are well separated in frequency, say by an octave or more, they are largely independent of each other and the full thickness of the splitter is available as backing for each panel in turn, instead of the half thickness as with symmetrical splitters. In the case illustrated in Fig. 16 it was desired to cover the range of frequency from 50-300 cycles per second in order to supplement the performance of porous splitters at these low frequencies. Resonances were provided at 60 and 200 cycles per second by sheets of 0·035-in. terne plate and 0·008-in. steel on frames 36 in. by 19 in. by 6 in. deep filled with rock wool. Another way of providing multiple resonance, so as to broaden the band of frequencies over which absorption is obtained, is to attach discrete masses, at definite spacings, to the cover sheet of a resonant-type absorber. One resonance is provided by the sheet, loaded by the masses, moving as a whole, and another by the masses remaining stationary and the small areas of sheet in between vibrating. The existence of these two modes of vibration has been confirmed by tests on absorbers 3-in. thick, filled with rock wool and having front cover sheets of 0·012-in. tin plate. With these lining the sides of a 12-in. wide brick duct, giving a 6-in. wide air space, a peak attenuation of 6·6 db. per foot was obtained at 165 cycles per second. When ⅜-in. steel B.S.W.S. nuts were attached to the outside of the tin-plate with beeswax, at spacings of 3·5-in. centres, attenua-

tions of 4·3 and 3·4 db. per foot were obtained at 105 and 315 cycles per second, respectively. Between these peaks the attenuation fell to 0·5 db. per foot at 210 cycles per second. Although these attenuations with multiple resonant absorbers are smaller than with the simple single-frequency type, the former may provide a more economic solution in the case of a noise consisting of a few outstanding components of low and constant frequency.

As with porous type absorbers, the correlation of predicted and experimental values of attenuation has been attempted. Moderately satisfactory agreement is obtained in the case of absorbers filled with medium-density porous material (9 lb. per cubic foot), but this is not maintained at lower densities, the values of attenuation given by Morse's theory becoming more optimistic with decreases in the density of the porous material. In the extreme case of air-filled absorbers, the divergence between predicted and experimental values is so great that Morse's theory becomes quite inadequate, as might have been expected since the conditions of this case differ widely from those considered by Morse.

LITERATURE.

Visible Speech. By RALPH K. POTTER, GEORGE A. KOPP, and HARRIET C. GREEN. D. Van Nostrand Company, Incorporated, 250, Fourth-avenue, New York, U.S.A. [Price 5 dols.]; and Macmillan and Company, Limited, St. Martin's-street, Strand, London, W.C.2. [Price 25*s.* net.]

SOUND being a function of a single variable, a sequence of sounds, such as a spoken sentence, can be translated into a displacement-time curve, as in the trace on an oscillograph screen or the groove on a gramophone record. Though all the essential details of the speech are contained in the trace, as is proved by playing back from the record, it is not possible to decipher its message by visual inspection of the trace. To enable this to be accomplished, some method must be devised for sorting out the information implicit in the trace and displaying it in such a manner that it can be interpreted by the eye. This problem was undertaken by the Bell Telephone Laboratories in 1941, and the manner in which it was successfully solved within three years is related in this book.

The method adopted is briefly as follows. The sound sequence to be depicted is recorded initially on a loop of magnetic tape and is played back repeatedly into a scanning filter, the pass band of which is traversed slowly across the audible-frequency spectrum. The filter output operates a stylus which makes a trace upon a band of electrically sensitive paper, wrapped round a drum. The tape loop and paper band are interlocked so that successive scanning cycles are recorded side by side. With this apparatus, termed a "sound spectrograph," a time-frequency-intensity pattern of a speech sample, lasting up to 2·5 seconds, can be built up in about 2·5 minutes. On the sound spectrograms the time axis extends horizontally, and frequencies, normally in 200 steps over the range 70 to 3,500 cycles per sec., appear vertically with the corresponding intensities in varying shades of grey. Regularly spaced vertical striations, corresponding to the pitch of the voice, punctuate the pattern, but are ignored in reading. In the more elaborate "direct translator," developed subsequently, twelve fixed filters, each passing a 300-cycle band, are arranged to form twelve separate luminous traces simultaneously upon a moving screen of phosphorescent material, the brightness in each trace revealing the instantaneous intensity of the corresponding speech component. This device permits of direct translation from audible to visible speech. Technical details of the equipment are omitted, but are to be found in the July, 1946, issue of the *Journal of the Acoustical Society of America*.

Since visible speech affords a natural phonetic transcription of speech sounds, the nature of the visible speech patterns is closely related to the manner in which such speech sounds are generated. The bulk of the book is devoted to a detailed study of the patterns of the different speech sounds and sound combinations, whereby their points of resemblance and difference can be classified and correlated with the mechanism employed in their production. The whole of Part II consists of the lesson units that formed the material for the training of selected groups of individuals in the reading of visible speech patterns. The patterns themselves are admirably reproduced and portray clearly the various distinguishing features; in particular, the manner in which a sound is modified by the sound with which it is combined. Though differences in articulation do affect the patterns, experience has proved that, if a person's speech can be understood aurally, his speech patterns can be read visually, provided that his delivery rate does not exceed 130 words per minute.

Part III discusses a number of actual or potential applications of visible speech. Though present limitations of equipment have precluded any extended exploration of its possibilities in the education of the deaf, a congenitally deaf engineer, who joined the training group in December, 1944, was able to carry on a telephone conversation with the aid of the translator on February 2, 1945. Applications to foreign languages are illustrated by visible-speech patterns of translations of the same short passage, spoken in 15 different languages. Other promising applications, as yet barely touched upon, suggest themselves in connection with vocal and instrumental music, animal, bird and insect sounds, and mechanical vibrations. Visible speech, the latest and perhaps the most brilliant among many contributions to acoustics that have originated from the Bell Telephone Laboratories, is a singularly appropriate one, for it realises an ambition dear to Alexander Graham Bell, which the technical resources of his day prevented him from realising.

Welding of Plastics. By G. HAIM and H. P. ZADE. Crosby Lockwood and Son, Limited, 20, Tudor-street, London, E.C.4. [Price 21*s.* net.]

A REALLY satisfactory means of joining plastic materials so as to permit the fabrication of articles that are too big or too complicated for economical manufacture in relatively small quantities by existing methods of integral moulding, opens up a vastly enlarged field of plastics application. Of several jointing processes still in course of development, welding offers the most interesting possibilities, but since it is still comparatively new, and since many important developments took place in Germany during the war, English literature on the subject is mainly confined to isolated papers and patent specifications. This volume is doubly important, therefore, as being probably the first book devoted exclusively to plastics welding, as well as having considerable intrinsic merits, among which a pleasing, readable style and an orderly presentation of information are noteworthy.

Both authors have carried out original research and industrial development in welding, and are well qualified to survey practically the whole of present knowledge with constructive criticism. They deal, in two introductory chapters, with the properties and technology of weldable plastics, directing attention mainly to a dozen thermoplastic materials, most of which contain the vinyl group and thereby gain importance as being derived from raw materials plentiful in Britain. The succeeding text treats, in turn, of the methods, scope and preferred materials for welding by hot gas jets, heated tools, high-frequency dielectric heating, mechanical friction, and finely-tipped flames. Brief reference is made to recent progress in the high-frequency welding of glass, and to the instructional courses and equipment adopted in Germany during the early war years for training plastic welders. The established scope of plastics welding over the range from medical-tablet packaging to chemical reaction plant of large size is admirably exemplified, along with accounts of representative welding instruments and production machinery, the text throughout being instructively illustrated.

Although this book is fully documented and manifestly comprehensive of present knowledge in its subject, the authors are unable to say much about the mechanical properties, characteristics and deficiencies of plastic welds. Admittedly, they mention the detrimental effects of overheating and of dressing on tensile strength, and refer to artifices for improving the strength of welded pipe joints, but the systematic study of engineering stresses and fatigue strength of plastic welds has evidently yet to be undertaken. Another rather disappointing omission is of welding applied to photo-elastic structural models. Most engineers, nevertheless, will find in this book a great deal of new and valuable information, which will prove a serviceable foundation for future studies of a subject wherein rapid progress may be confidently predicted.

Control Charts. An Introduction to Statistical Quality Control. By PROFESSOR EDWARD S. SMITH, M.E., Ph.D. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 3 dols.]; McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 15*s.*]

PROFESSOR SMITH'S book covers much the same ground as the book on *Control Charts in Factory Management*, by William B. Rice, which was reviewed on page 377 of our 163rd volume (1947). The plan is also very similar; it is a book intended for the practical application of statistical quality control in workshops and makes no attempt to go into the statistical theory underlying the formulæ for establishing control limits, beyond the frequency distribution curves for usual examples, such as the heights of random groups of men. The present book also suffers from the same disadvantage to the British reader of referring almost entirely to American work and standards on this subject. It may be remembered that Mr. Rice's book contained a very interesting chapter giving a number of illustrative case histories of control charts. Professor Smith has contented himself with a clear statement of the bare outline of the subject sufficient to enable its methods to be applied to straightforward inspection problems requiring classification either by variables or attributes.

This book can be regarded as a more intensive course in the subject, stripped of everything except essentials. Its distinguishing feature is the use of simplified mathematical formulæ and extensive tables to save labour in the evaluation of these formulæ. The text is based on standard intensive courses that were conducted during the war by the United States War Production Board, and is adapted for use by persons who are not familiar, or have lost touch, with the operations and practices of elementary algebra. It is quite understandable that such courses should have been of the greatest value during the war, when enormous quantities of standard articles were being produced in innumerable workshops; but there is a certain danger under normal conditions, when each executive will be considering the use of control charts for his own particular product, that the more or less mechanical application of these methods, without a full understanding, may lead to difficulties. For this reason it should be noted that Professor Smith's book does not devote so much attention to the all-important subject of the selection and grouping of samples as is really required by the executive, as distinct from the employee engaged in the routine business of making and using quality-control charts.

ELECTRICAL PLANT PROGRESS.—It has been announced by the Minister of Supply that a total capacity of 465·5 MW of heavy electrical plant was manufactured and erected in this country in 1947. Of this, 340 MW were brought into service and connected to the grid. The repair work completed during the last nine months of the year was equivalent to 1,293 MW.

BRITISH HYDROMECHANICS RESEARCH ASSOCIATION.—The future Director of Research of the British Hydromechanics Research Association is to be Mr. L. E. Prosser, A.K.C., B.Sc., A.M.I.Mech.E., who for the past nine years has been principal scientific officer in charge of the Fluid Mechanics Section of the Engineering Division of the National Physical Laboratory. He has been working in close connection with the Hydraulic Machinery Committee of the Mechanical Engineering Research Board established by the Department of Scientific and Industrial Research. When Mr. Prosser's present engagement with the National Physical Laboratory terminates, he will open the Association's offices at 78, Petty France, London, S.W.1. Until then, all communications should continue to be addressed to the Secretaries, Peat, Marwick, Mitchell and Company, 94-98, Petty France, London, S.W 1

THE ENGINEERING OUTLOOK.

VII.—The Rolling-Stock Industries.

In contrast with the improvements in coal and steel production, towards the end of 1947, the rolling-stock situation has deteriorated steadily. On November 18, Sir Stafford Cripps devoted an entire Press conference to the subject of wagon shortage, which he described as "extremely grave," and he followed this with an urgent appeal for a more rapid turn-round of wagons. The response showed that there existed considerable scope for a more efficient utilisation of available resources. Many factors contribute to a potential breakdown of rail transport, of which the shortage of wagons and locomotives is only one, though perhaps the most important. Shortage of staff and materials for operation and maintenance purposes, and the psychological unsettlement that was evident during the few months preceding the transfer of the railways to public ownership, must have rendered the solution of many transport problems more difficult. It remains to be seen how far the Railway Executive will be able to instil new vitality into their organisation, in order to avert a crisis; it is to be deplored that energetic action was not taken sooner. The present shortage of wagons and locomotives is certainly no new discovery: a year ago, in this series, the comment was made that "one of the most important factors in the post-war crisis of British industry has been and still remains an acute shortage of locomotives and railway wagons." This was largely the result of inadequate maintenance and deferred renewals during the five years of war, and the remedy lies in more materials and a higher output in railway workshops and in the private locomotive and wagon-building industries.

The figures given by Sir Stafford Cripps in November showed that there were 54,000 fewer wagons available for traffic than at the corresponding date in 1946 and over 86,000 fewer than in 1945. Nearly 200,000 wagons were under repair or awaiting repair. Sir Stafford pointed out that, in spite of the high priority given to repairs and the building of new wagons for steel and timber supplies, and

Table I.—*Production of Railway Wagons and Carriages.* (Numbers.)

Period.	Wagons.		Carriages.	
	Total.	For Export.	Total.	For Export.
1935	29,328	—	2,043	—
1944	21,304	—	233	—
1945	27,751	—	418	—
1946	39,354	11,389	838	15
1946, 1st Qr. ..	11,693	5,067	188	—
2nd Qr. ..	9,205	3,455	207	2
3rd Qr. ..	8,113	1,354	164	5
4th Qr. ..	10,343	1,513	279	8
1947, 1st Qr. ..	9,234	1,044	333	20
2nd Qr...	7,828	1,123	359	41
3rd Qr. ..	9,953	1,614	292	29
4th Qr. ..	10,000*	..	..	..

* Estimated.

particularly to cater for coal, the rate of deterioration of the existing wagon stock was outstripping both repair and replacement rates, even though the actual repair performance exceeded the pre-war rate. He expected that the monthly rate of repairs would be increased by 16,000, which would lead to a steady reduction of arrears; but, he said, "even allowing for the accelerated rate of repair of railway wagons it is estimated there will be a deficiency of 100,000 wagons to deal with coal, iron and steel, and general merchandise."

The wagon position was summarised in the Government White Paper *Capital Investment in* 1948 (Cmd. 7268) as follows:—"The provision of wagons to replace worn-out stock is the most important single investment required by the railways to-day. There are 350,000 (29 per cent.) wagons more than 35 years old which need increasingly frequent repairs. This is the result of inadequate replacement during the war years. Despite the fact that the number being repaired is of the order of 100,000 each week, much in excess of pre-war output, nearly 200,000 (15½ per cent.) are awaiting or undergoing repair out of a stock of 1,220,000. The only method of remedying this situation is to concentrate so far as possible on extensive replacement of the older wagons, and it is intended that the full railway programme of 48,000 new wagons should be allowed to proceed. This compares with an estimated intake of 31,000 in 1947, and is about one-third greater than the average annual intake for the four years before the war."

Figures showing the output of wagons, coaches and rail-motor vehicles, taken from the *Monthly Digest of Statistics* (December, 1947), are shown in Table I, herewith. Wagon output rose sharply in 1946, when more than 39,000 were produced, but it is unlikely that this figure will have been exceeded in 1947, though the estimate of 31,000 given in the White Paper is obviously too low. The output by private builders,* as recorded by the Ministry of

Table II.—*Production of Railway Wagons and Carriages by Private Makers.**

—	Wagons.		Carriages.		Total Value.
	Number.	Value (£1,000).	Number.	Value (£1,000).	(£1,000).
1946 ..	17,941	8,278·2	71	438·3	8,716·6
1st Qr. ..	4,493	2,329·1	—	—	2,329·1
2nd Qr. ..	4,121	2,042·2	2	15·8	2,058·0
3rd Qr. ..	4,185	1,705·5	17	108·0	1,813·5
4th Qr. ..	5,142	2,201·5	52	314·5	2,516·0
1947 (1st 3 quarters)	10,600	4,856·4	337	2,099·9	6,956·3
1st Qr. ..	3,627	1,563·8	89	552·2	2,116·0
2nd Qr. ..	3,020	1,402·5	138	877·8	2,280·4
3rd Qr. ..	3,953	1,890·0	110	669·9	2,559·9

* Excluding Royal Ordnance Factories.

Supply, is given in Table II, on this page, and shows a decline in 1947, particularly during the second quarter, when the number produced was only 67 per cent. of the average quarterly output for 1946. In that year, private makers accounted for about 45 per cent. of the total production, but, of this, 36 per cent. was exported. The percentage of production for export declined rapidly from nearly 52 per cent. during the first quarter of the year to 26 per cent. in the last quarter, but rose again to over 40 per cent. in the third quarter of 1947. This would appear at first sight to be unduly high in view of the seriousness of the shortage on the home railways, but the number exported is considered by manufacturers to be barely adequate to maintain their foothold in overseas markets. Any further reduction might well ruin the long-term prospects of an industry which, in pre-war years, depended on overseas markets for over a third of its total sales.

The priority for materials given to the wagon industry does not extend to carriages. The Capital Investment White Paper reports that the railways contemplated a large building programme of coaching stock, three times above current output, the cost of which might exceed that of the wagon programme. It recognises that there is much old stock in existence, more than 12,000 (about 20 per cent.) being over 35 years of age, but concludes "The justification for a high rate of replacement is not as strong as that for wagons, and it has been decided to limit the programme for the home railways for 1948 to the present output of 1,000 coaches per annum." Table I shows that the carriage output during the first three quarters of 1947 was at the rate of nearly 1,300 per annum, about 9 per cent. being for export. Private makers provided some 34 per cent. of the total.

The wagon-production target of 48,000 in 1948 involves a substantial expansion in output, most of which may have to come from privately-owned workshops. The immediate increase in repair output may curtail the railways' capacity for new building, since they have been working to the limit of their man-power resources; it is doubtful whether even an unrestricted supply of materials would allow a substantial increase in output. Much has been done to alleviate the situation by commissioning some Royal Ordnance Factories to assemble wagons, the parts and sub-assemblies being obtained from numerous firms, ranging from Dorman, Long and Company (who make underframes) to small general-engineering shops. New entrants to the industry include Head, Wrightson and Company, Limited, who now make complete 16-ton steel special-purpose wagons, and M. and W. Grazebrook, Limited, of Dudley, general engineers and iron-founders, who are building tank wagons for the British Petroleum Board. This increase in capacity has placed a heavy additional burden on manufacturers of wheels, axles, buffers, springs, etc., but some improvement was apparent in the supply of these items towards the end of the year. The Royal Ordnance Factories' output of about 1,000 wagons a month represented 85 per cent. of the average monthly production of private builders during the first nine months of 1947; but the loss of output directly attributable to the fuel crisis

Table III.—*United Kingdom Exports of Carriages and Wagons.*

—	1938.	1945.	1946.	1947.
	Weight (Tons).			
Carriages:				
Complete	2,174	173	270	2,354
Parts, other than axles, tyres and wheels	4,495	456	2,824	2,248
Wagons and trucks:				
Complete	39,078	7,441	97,623	48,540
Parts, other than axles, tyres and wheels	10,714	3,707	41,287	18,640
Axles, tyres and wheels	44,241	14,905	67,307	65,451
Total ..	100,702	26,682	209,311	137,233
	Value (£1,000).			
Carriages:				
Complete	278	29	82	748
Parts, other than axles, tyres and wheels	587	103	453	471
Wagons and trucks:				
Complete	1,591	359	5,017	4,525
Parts other than axles, tyres and wheels	505	259	2,759	1,571
Axles, tyres and wheels	1,191	560	2,741	2,891
Total ..	4,152	1,310	11,052	10,206

was considerable, being estimated at some three months' work, and it is expected, therefore, that the 1948 output will exceed substantially that of 1947.

Exports of wagons and carriages are given in Table III, the source being the *Trade and Navigation Returns*, December, 1947. It will be seen that the total tonnage exported during 1947, including axles, tyres and wheels for all rolling stock, exceeded the 1938 figure by 37 per cent., while the value of exports was 2½ times greater; but there was a decline from the figures for 1946 of nearly 35 per cent. in tonnage and 7 per cent. in value, which was almost entirely accounted for by a reduction of exports of complete wagons and parts. This probably reflects the Government policy of concentrating as much as possible of the available capacity and materials in the home market without relinquishing the export markets entirely to competitors. During 1946, the United States exported carriages and wagons valued at 12·8*l.* million, compared with British exports of 11·1*l.* million, Belgium coming third with 2·1*l.* million; so far as can be ascertained, no other country exported wagons and carriages valued at more than 1*l.* million.

There is no doubt that the world demand for rail transport is far in excess of world capacity. In the United States, railways are working with the same number of carriages and wagons as in 1940 and are handling a traffic volume fully 80 per cent. greater. In the beginning of 1947, the Office of Defence Transportation set a production target of 10,000 vehicles monthly for domestic use, and the railroads placed firm orders for 90,000 during the first eight months. This programme was far from being realised; in no recent month has output exceeded 8,000, and the railroads have done no more than replace war-worn stock, which, under normal conditions, would have been scrapped much sooner. The position at the end of 1947 was most confused. In its concern over the critical shortage, the Department of Justice decided to investigate

* This excludes the output of Royal Ordnance Factories, averaging about 1,000 wagons per month, but these are included in Table I.

the entire industry through the Courts for alleged anti-trust violations. A Senate committee took the step of calling manufacturers together, but no immediate solution seemed possible. The bottleneck is not in building capacity, assessed by the industry at 10,000 monthly, which could be increased, perhaps, to 14,000 by greater contributions from railroad building shops; the production ceiling is set by steel supplies, and the controversy on the anti-trust issue centres on steel deliveries. The steel makers assert, and the Office of Defence Transportation figures agree, that sufficient steel has been dispatched to attain an output of 10,000 units a month, and that steel earmarked for carriages and wagons has been sidetracked for locomotive manufacture and for coal-mine loading cars.

The European requirements under the European Recovery Programme were estimated at about 367 million dols., at a unit cost placed at 3,500 dols. The total for 1948 alone would have been 48,000 vehicles, but the President's Committee on Foreign Aid has recommended shipment of only 20,000 during 1948; even this reduced number will place a serious burden on United States capacity. The clamour for railway wagons, however, is world wide and little economic reconstruction can take place if requirements are not met. To meet the needs of Germany alone, 89,000 freight cars are said to be needed in 1948-49. Orders accepted by American manufacturers for France, the Argentine, South Africa, and other countries, were so large that the Civilian Production Administration had to impose, in January, 1947, an order prohibiting any freight-car builder from placing orders for steel to be used in the production of freight cars for export, on orders received after November 30, 1946, unless authorised by the C.P.A. The situation in Canada is hardly less critical. There are signs, however, that the European wagon and carriage building industries are recovering, particularly those of Belgium, Czechoslovakia, Italy and Poland. Belgium was exporting to the Netherlands, the Belgian Congo, and the Cameroons in 1947, and production was increasing rapidly. Czechoslovakia produced 1,400 freight cars monthly during the first quarter of 1947, but this figure declined to 1,300 a month during the second quarter, owing to a diversion of capacity to the output of railway coaches. There is no doubt that these countries will soon produce in excess of their own requirements and will compete with the United States, Britain and Canada for export markets as soon as their own rehabilitation is completed.

The best British markets during 1947 were British India, which accounted for over 14 per cent. of the total value of exports, followed by South Africa with about 1·5 per cent. These two countries were sent much smaller quantities in 1947 than in 1946 (12,473 tons compared with 79,285 tons), and a greater proportion of exports went to unclassified British countries. Exports to foreign countries were large. In 1946, consignments to France were valued at over 2*l.* million, but, in 1947, nearly all exports to foreign countries, like those to British countries, are unclassified, implying a more even distribution of available quantities all over the world—which probably means that builders are endeavouring to keep alive as many markets as possible until British conditions revert to normal.

Though the shortage of locomotives on the home railways is less acute than that of wagons, there are vast arrears of renewals. Towards the end of 1947, about 8,000 locomotives, or 39 per cent. of the total, were considered over-age, and were causing the railways great difficulty because of the rapidly increasing number of breakdowns. The White Paper on *Capital Investment in* 1948 summarises the position as follows: "Out of a present stock of approximately 20,500 locomotives, there are about 3,750 under and awaiting repairs at any one time, compared with about 3,300 at the outbreak of war. The full railway programme of nearly 600 new locomotives for 1948 is to proceed. The average intake for the four years before the war was 488." During 1947, an inter-departmental Working Party examined the future locomotive requirements of the home railways and drew up a five-year programme as shown in Table IV.

This programme has since been revised, as, according to the White Paper, the number to be built in 1948 has been raised from 450 to nearly 600. The production figures (from the *Monthly Digest of Statistics*, December, 1947), shown in Table V, herewith, show that total output in 1946, though less than in 1945, was about 800, of which 48 per cent. was built for export. The average quarterly output during the first nine months of 1947 fell short of the corresponding figure for the previous year by more than 20 per cent., but much of this can be attributed to the fuel crisis. During the first quarter of 1947, 142 engines were built, compared with 223 during the previous quarter and 178 during the following quarter. There is a possibility that the very heavy arrears of major repairs, and the rapidly growing incidence of breakdowns will prevent the railway workshops (now under the control of the Railway Executive) from reaching the targets set in the plan. Additional repair facilities cannot easily be found. In November, the Parliamentary Secretary to the Ministry of Supply, Mr. Jack Jones, announced that four Royal Ordnance Factories were working on spares and components for three main-line companies. It has also been arranged through the L.M.A. to effect major repairs on austerity locomotives at the Scotswood works of Messrs. Vickers-Armstrongs Limited, Newcastle-on-Tyne. It is expected that in the period March, 1947, to December, 1950, some 700 2-8-0 "Austerity" locomotives will have received major repairs and this substantial number will be put into operation on the old L.N.E.R. system (Eastern and North-Eastern Region of the British Railways). To go farther would be difficult, as these plants are not equipped for the complete overhaul of locomotives; neither are the private builders' workshops, so that their contribution also, in the main, has been limited to the supply of spares and components. Although figures are not available for the last quarter of 1947, it is probable that the target of 387 locomotives for the year will have been reached. Private builders supplied 170, and railway workshops required to produce less than 50 during the last quarter, having averaged 58 per quarter during the first nine months.

Table IV.—*Locomotive Requirements of Home Railways.*

Year.	No. of Locomotives Required.	To be Built by Railway Companies.	To be Built by Private Builders.
1947 ..	387	222	165
1948 ..	450	305	145
1949 ..	590	450	150
1950 ..	782	450	332
1951 ..	782	450	332

Table V.—*Production of Locomotives by Private Builders and Railway Companies.*

Period.	Main Line.		Industrial.		Total.	
	Total.	For Export.	Total.	For Export.	Total.	For Export.
1935 ..	738	141	..	..	..	..
1944 ..	1,070	..	45	..	1,115	..
1945 ..	786	139	43	..	829	..
1946 ..	726	358	70	24	796	382
1946—						
1st Qr. ..	157	87	15	9	172	96
2nd Qr. ..	198	104	22	4	220	106
3rd Qr. ..	167	90	14	4	181	94
4th Qr. ..	204	77	19	7	223	84
1947—						
1st Qr. ..	132	49	10	—	142	49
2nd Qr. ..	163	46	15	2	178	48
3rd Qr. ..	146	68	9	—	155	68

Locomotive-building capacity is roughly divided in the proportion of 2 to 1 between private builders and railways, though, immediately before the war, private builders employed only one-third of the labour engaged on locomotive building and repair in railway workshops—about 12,000 to 13,000, compared with 36,000 to 38,000. Between 1929 and 1938, however, the number of new locomotives built by the railway companies averaged 311, whereas the private industry, working at well under half its potential capacity, averaged 350 locomotives per annum between 1935 and 1939. The five-year plan quoted above envisages an annual output of 450 locomotives by railway workshops from 1949 onwards. This obviously assumes, somewhat optimistically, that the arrears of repairs and rebuilding will have been overtaken by then. The contribution from private builders is fixed at 145 for 1948 (156 will probably be completed), 150 in 1949 and 332 from 1950 onwards. At present, orders have been received only for 1948 and for part of the 1949 quota (66 locomotives out of 150).

Little information is available in respect of locomotive building by the railway companies. In 1946, the number of locomotives built averaged 74 per quarter; in the first nine months of 1947, this figure dropped to an estimated 58. Shortages of labour, materials and the fuel crisis are generally put forward as the principal factors responsible for the drop. The production figures for the private building industry, given in Table VI, on this page, for 1946 and 1947, have been compiled from the records of the Ministry of Supply and the Locomotive Manufacturers' Association. The quarterly figures reveal the adverse effect of the fuel crisis, and show that, towards the end of last year, production had gathered momentum. It is expected that, during 1948, about 500 will be built, and that, in 1949, the numbers produced will increase rapidly if adequate supplies of labour and materials can be secured. The Locomotive Manufacturers' Association estimate that, in 1947, the industry was working at some 60 per cent. of its normal capacity—this being between 800 and 1,000 locomotives per annum, the number varying according to types, length of runs, complexity of designs, customers' specifications, etc. The maximum capacity of the industry, granted a labour force of 19,000 working two shifts (compared with 11,260 at present, with little or no shift work) is estimated at about 1,200 locomotives, or locomotive equivalents. Granted an adequate demand, the industry plans to reach this production figure by 1952, increasing its labour force and introducing two-shift working gradually. This would provide at least 900 locomotives for export markets, compared with 374 in 1946 and 260 in 1947. It also pre-supposes a steady load from the home railways, exceeding 300 locomotives per annum. External factors, such as competition from the United States, Canada, Czechoslovakia, etc., are not encouraging, though orders from the Crown Agents may help a great deal; but the industry is far from confident even regarding orders from the home railways.

TABLE VI.—PRODUCTION OF LOCOMOTIVES BY PRIVATE BUILDERS.

—	Number.			Value (£1,000).*			Percentage for Export.
	Main Line.	Total.	Industrial.	Home.	Export.	Total	
1946, 1st Qr. ..	—	107	—	72	1,731	1,803	96·0
2nd Qr.	—	145	—	359	1,952	2,311	84·5
3rd Qr. ..	—	130	—	385	1,633	2,018	80·9
4th Qr. ..	—	129	—	497	1,731	2,228	77·7
1946 Total ..	430	511	81	1,313	7,047	8,360	84·0
1947, 1st Qr. ..	—	91	—	446	1,056	1,502	70·3
2nd Qr. ..	—	126	—	875	947	1,822	52·0
3rd Qr. ..	—	106	—	521	1,273	1,794	71·0
4th Qr. ..	—	148	—	820	1,310	2,130	61·5
1947 Total ..	395	471	76	2,662	4,586	7,248	63·4

* Contract values, subject to price fluctuations prior to delivery.

The division of private builders' output between home and export has constituted one of the main problems that the Government have had to face in

planning the nation's industrial rehabilitation and overseas trade. The obvious temptation was to force private builders to concentrate on building for the home railways, and to convert part of their capacity to the repair and rebuilding of locomotives previously supplied by them to the home railways. This was well resisted on the whole, and rightly so, since, as their distribution shows, exports have been a vital factor in securing food, materials and maintaining goodwill in important markets. It will be seen from Table VI, that the percentage exported fell from 84 per cent. in 1946 to 63 per cent. in 1947; but plans for 1948 show that at least 65 per cent. of the total number produced will be shipped overseas.

The best British markets for locomotives in 1947 were India, Burma and British Africa. Altogether, more than 87 per cent. of the total value of shipments went to British countries. There has been a sharp decline in the exports to the Argentine, which was by far the most important foreign market before the war, and in those to the Union of South Africa. In both these markets, as in India, United States manufacturers have gained considerable ground, and it is questionable whether the British builders will succeed in regaining their former predominance. At present, delivery dates are probably the most important factor in obtaining orders and are immensely to the advantage of American steam-locomotive builders, who have much redundant capacity following the big switch-over of railroad orders to Diesel-electric locomotives. The large builders of steam locomotives are gradually adjusting their capacity to the new demand, but there remains a surplus which is being exported in competition with British builders. The fact that the United States may eventually cease to build steam locomotives, or so reduce its capacity as to be no longer in a position to supply spares, does not appear to have acted as a deterrent to those countries in urgent need of locomotives.

The Locomotive Manufacturers' Association's overseas travelling representative has returned recently from a trip embracing the Indian and Argentine markets. He reported a huge unsatisfied demand, but could do little owing to the lengthy delivery dates quoted by British manufacturers. Orders so far received from the Argentine total 75 and, from India, 384, main-line locomotives. Altogether, the Locomotive Manufacturers' Association have recorded firm orders for over 950 locomotives from overseas markets, and 340 for the home railways. Further large orders may be received from the Argentine, where a five-year plan has been announced, involving the placing of orders for over 300 locomotives. Although delivery dates will be important, and in spite of the difficulties encountered by the recent British trade mission under Sir Clive Ballieu, it is probable that the British industry would be given a substantial part of the order if agreement can be reached regarding the date of delivery. The granting of any priority, however, is unlikely, as this would disrupt work in hand, and would affect seriously the goodwill of the many other customers on whose orders the British industry depended during the inter-war period. The industry is justifiably reluctant to interfere with contracts already drawn up, and this may well be a stumbling block to the Government's efforts to reach bilateral trading agreements with primary producing countries, which almost inevitably demand locomotives and railway wagons in part-payment for their food surpluses. A recent example of this is the Russian agreement, which involves the supply of 1,100 industrial locomotives for work in forests. Though arrangements have not been finally settled, it is probable that the order worth over 7*l.* million, will be executed by the North British Locomotive Company, who, for this purpose, will re-open their Atlas Works in Glasgow. Components and sub-assemblies will be sub-contracted out, both within and outside the industry, and the North British Company will act mainly as assemblers. This raises the problem, now common to the entire British capital-goods industry, of fulfilling very large orders placed by foreign governments, when there is no assurance that such orders will be repeated within the next five years. The early delivery dates invariably demanded must force manufacturers either to disrupt their forward programme or to look for sub-contracting space outside their own industry, or both. Many feel that this is not worth while and would gladly decline these orders.

British exports of locomotives and parts are given in Table VII, above, compiled from the *Trade and Navigation Returns*, December, 1947; and international exports of locomotives and parts are given in Table VIII, from Board of Trade figures. American exports in 1946 totalled over 45*l.* million, compared with British exports of 10·3*l.* million. The only other important competitor was Sweden, whose exports during that year totalled 1·4*l.* million. It will be seen from Table VIII that American exports expanded rapidly during the war and it is expected that their locomotive exports during 1947 will constitute a record.

Competition in overseas markets during the next decade will involve supplying Diesel-electric locomotives, which are rapidly gaining in favour. The British industry was a late starter in this field, compared with its American competitors, but, during 1947, a special Internal Combustion Group was organised within the Locomotive Manufacturers' Association, to take care of the interests of Diesel-locomotive manufacturers. This group is divided into four sub-groups catering, respectively, for manufacturers of main-line locomotives, industrial and underground mining locomotives, contractors' locomotives of under 50 h.p., and railcars. The group includes many L.M.A. members who are now turning over some of their capacity to the manufacture of Diesel locomotives, and others, such as the Hunslet Engine Company, who have been established in this field for some considerable time, but it also includes new members, such as the Brush Electrical Engineering Company, the English Electric Company, Harland and Wolff, Ruston and Hornsby, F. C. Hibberd, and others. It is hoped that this will enable the British industry to increase its overseas sales of Diesel-electric locomotives.

The most spectacular technical developments during 1947 concerned the application of the gas turbine to rail traction. It was announced during the year that the Great Western Railway was experimenting with a gas-turbine electric locomotive, to have a turbine developing at 2,600 effective horse-power, and six driving motors. In his presidential address to the Institution of Locomotive Engineers last December, Mr. Julian Tritton dealt with the potentialities of gas turbines for rail traction, with particular reference to gas turbines using pulverised fuel. Much research is at present going on in this field in the United States, and it is possible that, during the next five to ten years, the gas turbine will challenge the ascendancy of the Diesel-electric locomotive as seriously as the latter is now challenging that of steam. The United States railroads' policy of complete conversion to Diesel-electric traction has not been followed in Britain, although the Southern Railway and the L.M.S. are experimenting with Diesel-electric locomotives for the haulage of high-

TABLE VII.—EXPORTS OF BRITISH LOCOMOTIVES FOR SELECTED YEARS. (£1,000.)

Countries.	1913.	Per Cent.	1921.	Per Cent.	1929.	Per Cent.	1933.	Per Cent.	1937.	Per Cent.	1946.	Per Cent.	1947.	Per Cent.
British India, Burma, Ceylon and Dependencies, and Malaya	946	33·9	4,469	47·0	2,735	52·3	400	33·1	398	20·3	2,950	30·6	1,717	21·9
British Africa	318	11·4	2,152	22·5	650	12·4	47	3·8	501	25·5	2,104	21·8	212	2·7
Australia	267	9·6	62	0·6	77	1·4	11	0·8	33	1·7	—	—	—	—
New Zealand	—	—	306	3·2	6	0·1	4	0·2	85	4·3	53	0·5	16*	2·2
Canada	—	—	—	—	24	0·5	1	—	—	—	—	—	—	—
Other British Countries	100	3·6	581	6·1	172	3·2	35	2·8	80	4·0	1,481	15·3	4,883	62·5
China	10	0·4	329	3·4	67	1·2	131	10·8	13	0·6	—	—	—	—
U.S.S.R.	1	—	—	—	—	—	250	20·6	—	—	—	—	—	—
Portuguese Africa and India	48	1·5	90	0·9	83	1·5	1	—	58	2·9	—	—	—	—
Egypt	14	0·5	—	—	39	0·7	11	0·8	175	8·9	—†	—	—	—
Argentine	696	25·0	527	5·5	329	15·7	238	19·6	180	9·2	163	1·7	220*	2·8
Colombia	4	0·2	9	0·1	15	0·2	2	0·1	26	1·2	—	—	—	—
Peru	6	0·2	—	—	37	0·7	2	0·1	76	3·9	—	—	—	—
Brazil	79	2·8	86	0·8	159	3·0	20	1·5	241	12·3	—	—	—	—
Chile	74	2·7	51	0·5	50	0·9	1	—	5	0·2	—	—	—	—
Other Foreign Countries	229	8·2	890	9·4	325	6·2	71	5·	99	5·0	2,902	30·1	754	9·8
Total	2,792	100·0	9,55	100·0	4,768	100·0	1,225	100·0	1,970	100·0	9,653‡	100·0	7,802‡	100·0

* Excluding main-line locomotives, separate figures being given in the *Trade Returns*; locomotives shipped to these countries, therefore, are included in "Other British" or "Other Foreign" countries.
† Less than £500.
‡ Totals for 1946 and 1947 include only main-line locomotives and parts, excluding wheels, tyres and axles and industrial locomotives; the latter were valued at £714,141 and £768,058, respectively.

TABLE VIII.—INTERNATIONAL EXPORTS OF LOCOMOTIVES AND PARTS (MAIN EXPORTING COUNTRIES ONLY).

Country.	1938.		1939.		1940.		1941.		1942.		1943.		1944.		1946.	
	£1,000.	Per Cent.	£1,000.	Per Cent.	£1,000.	Per Cent.	£1,000.	Per Cent.	£1,000.	Per Cent.	£1,000.	Per Cent.	£1,000.	Per Cent.	£1,000.	Per Cent.
United Kingdom	2,829	38·6	2,563	38·5	1,443	27·1	1,159	27·9	749	6·6	954	3·2	1,802	4·7	10,365	18·0
Germany	2,940	40·3	2,900	43·6	1,455	27·3	1,660	34·4	2,020	17·8	6,450	21·5	1,635*	4·3	—	—
United States	1,240	16·8	766	11·5	1,750	32·8	1,655	34·3	6,900	60·8	19,700	65·8	32,100	84·6	45,331	79·0
Belgium	100	1·4	58	0·8	6	0·1	—	—	—	—	—	—	—	—	—	—
France	200	2·6	353	5·3	633	11·8	235	4·8	1,570	13·9	2,760	9·1	2,453	6·4	217	0·4
Sweden	23	0·3	12	0·2	28	0·5	11	0·2	45	0·4	4	—	—	—	1,380	2·3
Switzerland	—	—	9	0·1	23	0·4	112	2·4	60	0·5	137	0·4	22	—	177	0·3
Total	7,332	100·0	6,661	100·0	5,338	100·0	4,832	100·0	11,344	100·0	30,005	100·0	38,012	100·0	57,470	—

* First six months only.

EXPRESS MIXED-TRAFFIC LOCOMOTIVE; L.N.E.R.

MR. A. H. PEPPERCORN, M.I.MECH.E., CHIEF MECHANICAL ENGINEER.

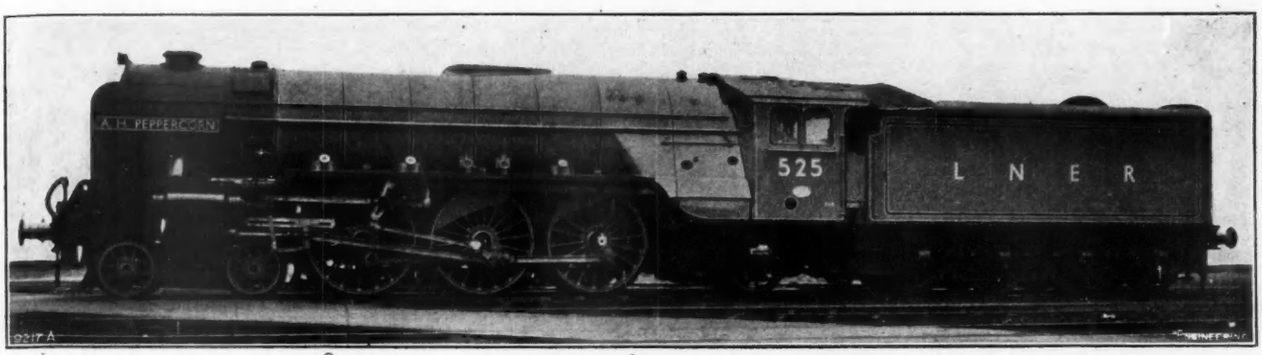
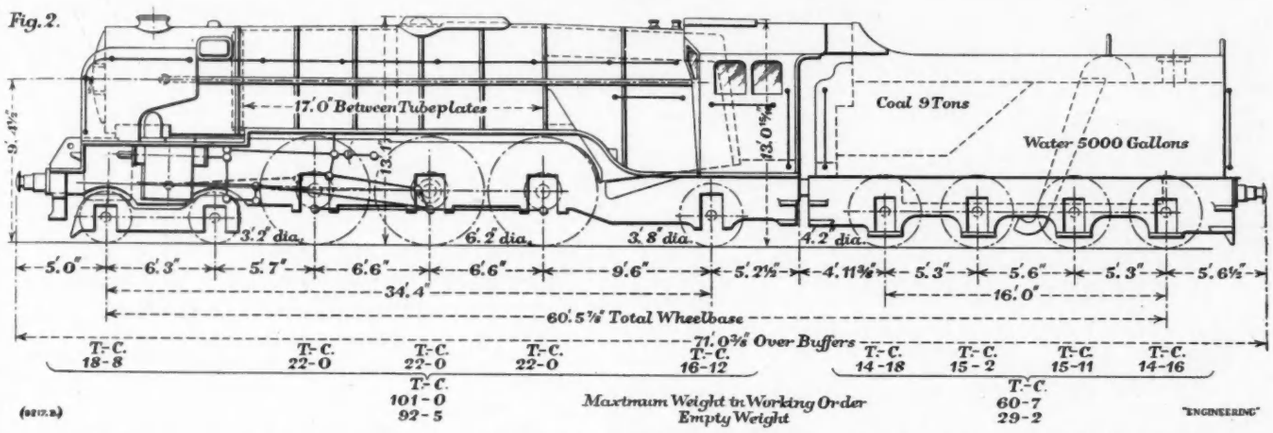


FIG. 1.

Fig. 2.



speed long-distance passenger trains. The L.M.S. locomotive, 62 ft. long and weighing 120 tons, has a 1,600-h.p. Diesel-driven generator supplying current to six axle-hung traction motors, mounted on two six-wheel bogies. It is proposed that this locomotive will go into fast passenger service between Derby and St. Pancras, and later between Manchester and St. Pancras. When the second unit is completed, it is the intention that both shall be coupled together and take up express passenger service on the Euston-Glasgow main line. The intention is to obtain comparative performances with the new 4-6-2 steam locomotives recently placed in service. It is not expected that there will be a rapid conversion to Diesel-electric traction on the home railways, but it is evident that the British locomotive industry must ensure its future by keeping abreast of all developments and spending a much greater proportion of its turnover on research and development work.

THE ELECTRIC HEATING OF GLASS HOUSES.—In a paper on "The Application of Electricity to Horticulture," read by Messrs. C. A. Cameron Brown and E. W. Golding before the Installations Section of the Institution of Electrical Engineers on February 12, it was stated that to maintain commercial tomato houses in the Lea Valley at a temperature of 55 deg. F. during an average March would require a consumption of 200,000 kWh per acre. On a national scale the connected load might be 3,700 MW and the consumption, during the same month, 220 million kWh.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.—A sub-committee of the Incorporated Municipal Electrical Association has been considering the future of that body, in view of the changes that will be brought about by the Electricity Act, 1947. It has been decided to send a memorandum to the British Electricity Authority advocating the establishment of a body to represent consumers' interests. A meeting will be held on Thursday, February 19, to discuss an amendment to the Association's Memorandum of Association, enabling it to give financial assistance to any new organisation which may be formed for that purpose.

NEW "A2" CLASS EXPRESS LOCOMOTIVE, L.N.E.R.

ALTHOUGH the locomotive to be described will doubtless operate in the Eastern, North Eastern, and Scottish Regions of British Railways, it was built at Doncaster works and put into traffic by the London and North Eastern Railway Company before that company was nationalised on January 1, 1948; it is therefore the last class of locomotive to be designed and built by the L.N.E.R. The locomotive has a 4-6-2 wheel arrangement, and the design is based on previous Pacific-type locomotives. It has been classified A 2, and the former A 2 class,* built by Mr. Edward Thompson in 1946, has been redesignated A 2/3. The engine is numbered 525, and was named "A. H. Peppercorn," after the chief mechanical engineer, by Sir Ronald Matthews, chairman of the L.N.E.R., at a ceremony at Marylebone station on December 18, 1947. It is the 1,434th, and the last, locomotive to be built by the L.N.E.R. since the formation of the company 25 years ago. A photograph of the engine is reproduced in Fig. 1, on this page, and an outline drawing in Fig. 2.

The A 2 locomotive has been designed for hauling express passenger and freight trains; the diameter of the driving wheels is 6 ft. 2 in., which is similar to that of the A 2/1, A 2/2, and A 2/3 classes, and is suitable for mixed traffic, being 6 in. less than the 6 ft. 8 in. of the express-passenger A 1 series. In the A 2/3 class, the outside cylinders are between the bogie and the leading coupled wheels, but in the new A 2 locomotive the outside cylinders have been placed over the bogie. The external exhaust pipe of the A2/3 class has therefore been eliminated, and the exhaust passages thereby shortened. The bogie has been placed 2 ft. 7 in. closer to the coupled wheels; otherwise the wheelbase of the engine and tender is the same as that of the A2/3.

As before, the drive is divided, the inside piston acting on the leading coupled axle, and the outside pistons driving the intermediate axle. The inside connecting rod and Walschaerts motion are the same as those used on the A 2/3, but the outside gear has been lengthened, and closely resembles that of the B 1 4-6-0 mixed-traffic class. On the A 2 locomotive, the outside slide bars are supported by a bracket in front of the leading coupled wheels, and the expansion link is pivoted on another bracket between the leading and intermediate wheels. This differs from the combined slide-bar and expansion-link bracket of the A 2/3 class. The cylinders are 19 in. in diameter and the piston stroke is 26 in. The piston valves are 10 in. in diameter; they have a maximum travel of 6¾ in., and a steam lap of 1⅛ in., and the cut-off in full gear is 75 per cent. The tractive effort at 85 per cent. boiler pressure is 40,430 lb., the adhesive weight is 147,840 lb., and the factor of adhesion is therefore 3·69.

The boiler is unaltered in general dimensions, and works at a pressure of 250 lb. per square inch. The barrel plates have been made lighter by using 3-per cent. nickel steel, and an L.N.E.R.-pattern steam collector has been provided instead of a dome. The principal dimensions of the boiler, which are the same as those of the A 2/3 boiler, are: length of barrel between tubeplates, 17 ft.; grate area, 50 sq. ft.; 121 2¼-in. outside diameter tubes; 43 5½-in. superheater flue tubes; firebox heating surface, 245·3 sq. ft.; tube heating surface, 1,211·57 sq. ft.; flue heating surface, 1,004·5 sq. ft.; total evaporative surface, 2,461·37 sq. ft.; superheater surface, 679·67 sq. ft.; and total heating surface, 3,141·04 sq. ft. A hopper ashpan, rocking grate, and self-cleaning smokebox are fitted. The boiler mountings, and the controls, are to L.N.E.R. standard patterns, but electric lighting is provided for the cab and head lamps. Current is provided by a Stone's turbo-generator on the front right-hand side of the footplate. The cab is wider than in the A 2/3 class; it has therefore been possible to lower the vacuum ejector, and, together with a V-front cab, this considerably improves the look-out.

* See ENGINEERING, vol. 162, page 175 (1946).

BANKSIDE POWER STATION.—In reply to a question by Mr. E. H. Keeling in the House of Commons on Thursday, February 5, the Minister of Fuel and Power (the Rt. Hon. H. T. N. Gaitskell) said that the pilot gas-washing plant, which would be used to determine the most efficient type of installation for the Bankside power station, was expected to be ready for operation in May. He confirmed that the elimination of sulphur from the fumes was a *sine qua non* of the scheme.

KHEDIVIAL MAIL LINE PASSENGER STEAMER "EL MALEK FOAD."

MESSRS. JOHN I. THORNYCROFT AND COMPANY, LIMITED, LONDON.

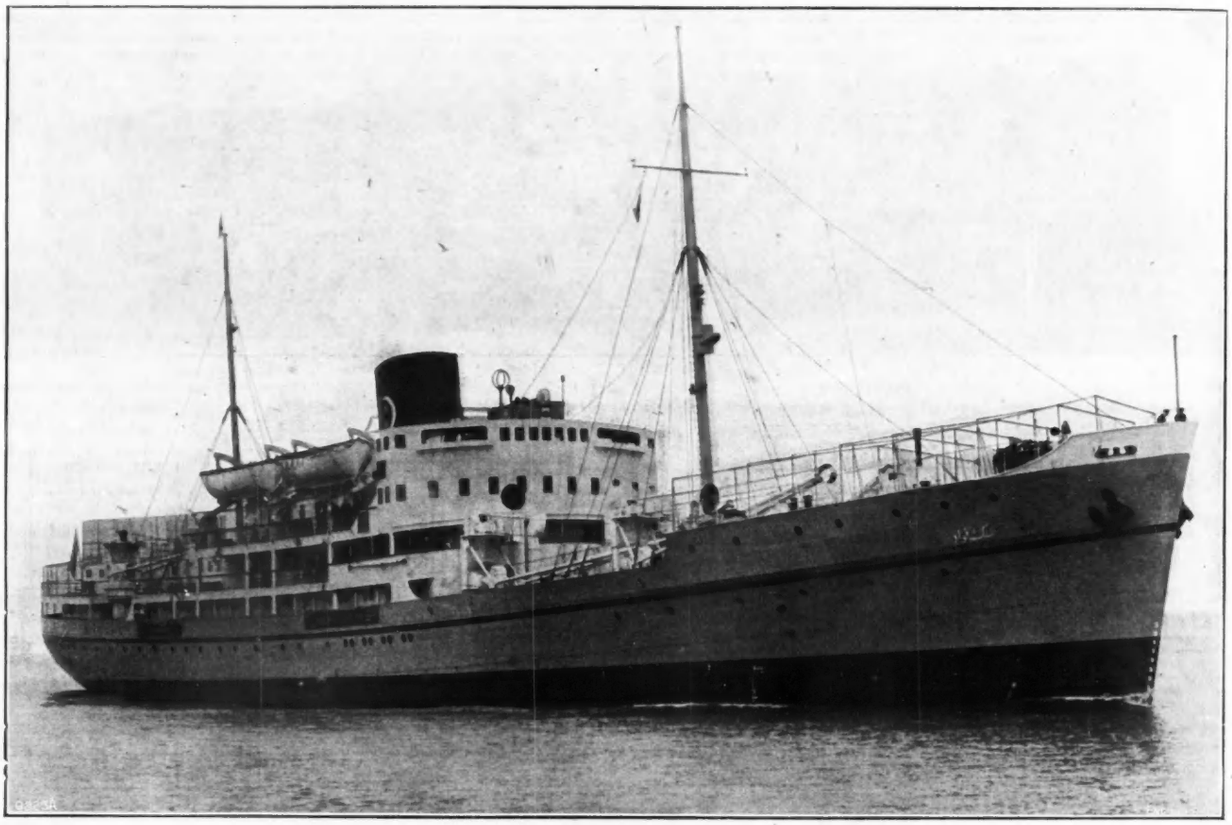


FIG. 1. VESSEL ON TRIALS.

KHEDIVIAL MAIL LINE PASSENGER STEAMER "EL MALEK FOAD."

BUILT at the Woolston shipyards of Messrs. John I. Thornycroft and Company, Limited, for the Khedivial Mail Line, the cargo and passenger steamer El Malek Foad has now completed her trials and was handed over recently to the owners. The vessel has been constructed for use on the passenger and mail service between Alexandria and Marseilles, and the photograph, reproduced in Fig. 1, above, was taken during her acceptance trials. Provision has been made for the accommodation of approximately 150 passengers in two classes, and, in addition, some 1,800 tons of cargo may be carried.

The design of the vessel was prepared by Messrs. John I. Thornycroft in collaboration with the owner's representatives and consultants, Sir J. H. Biles and Company, so as to ensure that the requirements of the intended service were met. The vessel has a designed speed of 18 knots, the length overall is 357 ft. 9 in., the moulded depth 28 ft. and the breadth 50 ft., while the displacement tonnage is approximately 5,200. There are two complete decks, namely, the upper and second decks, and, in addition, there is a deck extending forward and aft from the machinery space, a promenade deck and the boat deck. The hull is divided into six main compartments by five watertight bulkheads which terminate at the upper deck and there is a continuous double bottom arranged for the carriage of fresh water, water ballast and fuel oil. In addition, deep fresh-water tanks are arranged in No. 3 hold below the third deck, or tunnel flat, while the fore and aft peaks are arranged for the carriage of water ballast; deep oil-fuel tanks are situated across the vessel between the forward end of the machinery space and No. 2 hold. Altogether there are three cargo holds, two forward and one aft of the machinery space, each hold having corresponding 'tween-deck spaces to the underside of the upper deck. The cargo spaces are served by electric cranes manufactured by Messrs. Stothert and Pitt, Limited, Bath, there being two 5-ton cranes at number 2 spaces and two 3-ton cranes at numbers 1 and 3 spaces, respectively. The two cranes at number 1 space are illustrated in Fig. 9, on page 156. The cranes are self-contained and fully luffing, the operators being situated on the top platforms and moving round with them.

The vessel is engined by Parsons-type steam turbines arranged to drive twin screws through double-helical single-reduction gearing. The turbines have been built by Messrs. Thornycroft, and have been designed to give a maximum output of approximately 8,000 shaft horse-power at a propeller speed of 250 r.p.m.; the reduction gearing, however, was manufactured by Messrs. Parsons. There is a high-pressure turbine and a low-pressure turbine for each screw, the high-pressure turbines being of the impulse-reaction type while the low-pressure turbines are fitted with reaction blading only. Each high-pressure turbine consists of one double-bladed impulse wheel and five stages of reaction blading, there being seven rows of blading for each stage. There are 19 nozzles giving a total area of 3·25 sq. in., the designed output being 1,750 h.p. at 3,533 r.p.m. under normal conditions, and 1,880 h.p. at 3,695 r.p.m. on overload. The low-pressure turbines are fitted with 10 stages of reaction blading comprising three rows for the first three stages, two rows for the next four stages and a single row for each of the last three stages, making 20 rows in all. The designed output is 1,750 h.p. at 2,691 r.p.m. under normal conditions and 2,120 h.p. at 2,815 r.p.m. on overload. In addition, a three-row astern-impulse turbine is incorporated in each low-pressure turbine casing and these are designed to develop 40 per cent. of the full-ahead power. The forward end of the port low-pressure turbine casing can be seen in Fig. 11, on page 156, which is a general view of the engine-room control platform. The main condensers are also partly visible in this illustration; they are of the Weir regenerative type.

The most interesting feature of the El Malek Foad, however, is that it is the first vessel to be fitted with Messrs. Thornycroft's new design of boiler. Two boilers are fitted and these are of the three-drum, single-sided pattern in which one side, together with part of the front and back of each boiler is fitted with radiant-heat tubes only while the other side in each case contains the main generating tubes, together with the superheaters over which pass the products of combustion. This arrangement is shown in Fig. 2, opposite, which is an athwartship cross sectional elevation through the port boiler. The main advantage claimed for this design is that a more rapid flow of gases is obtained, resulting in better heat transfer. The boilers have been designed for a working pressure of 300 lb. per square inch and, as will be seen from Fig. 2, each consists of an upper steam and water drum and two lower water drums, both of which are connected to the upper drum by a system of steam-generating tubes. The radiant-heat tubes and the first two rows of the main generating bank have a diameter of 1¾ in. while the remainder of the main generating bank consists of two rows of 1¼-in. diameter tubes and 17 rows of 1-in. diameter tubes, the total heating surface for one boiler, excluding the superheater tubes, being 4,070 sq. ft. The main bank of tubes for each boiler is located towards the centre line of the ship, and the water supply to the outboard lower drums is taken, in each case, through four 4½-in. diameter unheated downcomer pipes. The weight of each boiler is taken by four stools fitted to the water drums and each pair of stools is provided with athwartship tie-bars which ensure the rigidity of the structure and limit the spread-deformation of the tubes when the boilers are hot.

The superheater tubes run in a longitudinal direction through spaces formed between the main generating tubes. This arrangement can be seen in Figs. 2 and 4, opposite, the latter being a section through the main generating tubes, in the plane indicated by the arrows AA in Fig. 2. On each boiler, a steam downtake pipe is led from the highest point of the steam drum to the upper, or inlet, connection of the front superheater header. At mid-length of each front header there is a diaphragm plate which divides the header into two separate parts and causes the inflowing steam to pass through the upper half of the superheater-tube bank into the rear header. The steam then returns through the lower half of the tube bank to the lower portion of the front header and thence to the stop and safety valves, which are of Cockburn's full-bore type. The headers have a diameter of 10 in., and the total heating surface of each superheater is 710 sq. ft. Under normal conditions, the temperature of the superheated

BOILERS FOR S.S. "EL MALEK FOAD."

MESSRS. JOHN I. THORNYCROFT AND COMPANY, LIMITED, LONDON.

Fig. 2.

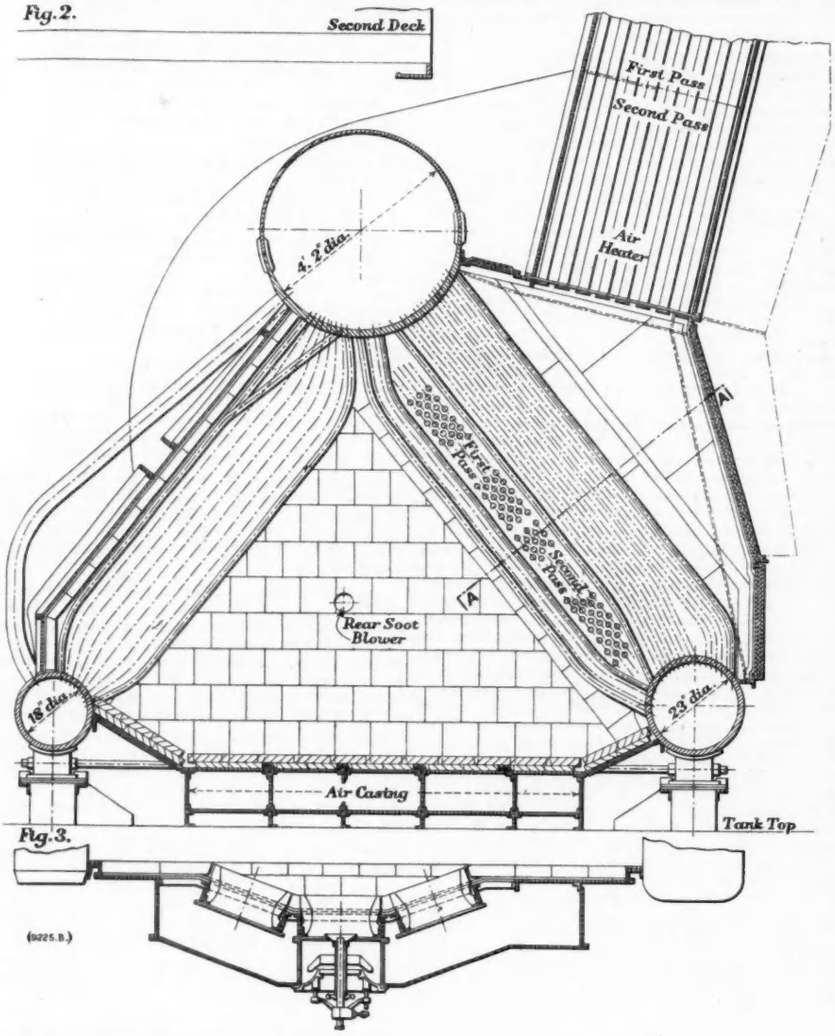


Fig. 3.

Fig. 4. SECTION A.A. Fig. 2.

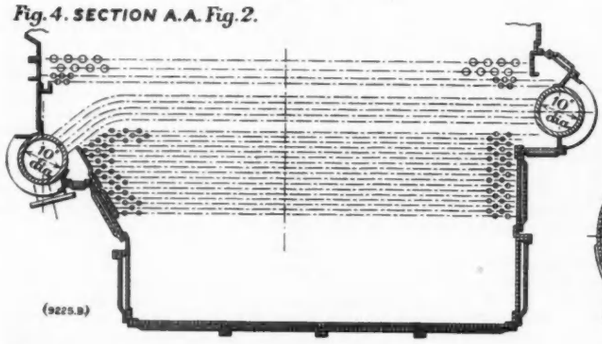


Fig. 7.

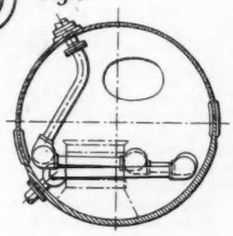


Fig. 5.

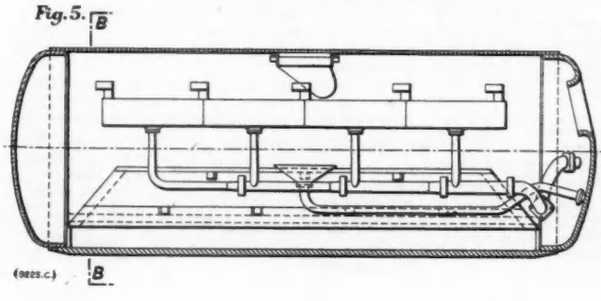
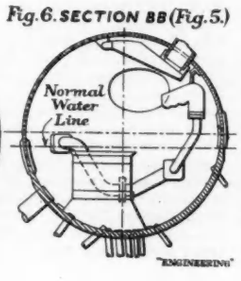


Fig. 6. SECTION BB (Fig. 5.)



steam is 685 deg. F., while the total evaporative capacity for both boilers is 85,080 lb. per hour with a fuel consumption of 5,710 lb. per hour.

Each steam drum is fitted with a baffle box which encloses the upper ends of the tubes in which there is a high rate of steam generation. The baffle box for the starboard boiler can be seen in Figs. 5 and 6, which show longitudinal and transverse cross sections, respectively, through the starboard steam drum. The object of the baffle box is to prevent the bulk of the rising steam bubbles from coming into contact with the relatively-cool feed water. The feed water is distributed through troughs situated in the top of the steam drums, the trough fitted to the starboard steam drum being shown in Figs. 5 and 6. The trough is divided longitudinally into four separate compartments, the feed water being supplied equally to the compartments by the feed pipe and branches visible in the illustrations. The feed water cascades from the main trough into three lower, or subsidiary, troughs which, like the main trough, are divided longitudinally into four compartments, and each subsidiary trough is drilled uniformly along the length with small holes. It will be realised that, with this arrangement, the entering feed water will be distributed over the water surface in a series of small streams, the number of subsidiary troughs in operation depending on the quantity of feed water supplied. The feed water is delivered by two Weir reciprocating feed pumps, each of which is designed to deliver 48,500 lb. of water per hour, the bore and stroke of the pump cylinders being 8 in. and 22 in., respectively. In addition, there is an auxiliary feed pump which, in emergency, can supply both boilers, the delivery being 100,000 lb. per hour. The feed water is heated in a Weir Multiflow-type heater which, by using 14,600 lb. of steam per hour at 20 lb. per square inch, can raise 97,000 lb. of water per hour from a temperature of 100 deg. F. to 240 deg. F.

Each steam drum is fitted with three groups of de-superheating tubes which are arranged below the surface of the water. The relative positions of the de-superheater tubes are shown in Fig. 7, but, in order to make the drawings clearer, they have been omitted from Figs. 5 and 6. Each group of tubes extends approximately along the length of the drum and the tubes are expanded into steel headers. The three elements in each case are connected in series by flanged pipes, this form of construction having been adopted to facilitate removal and cleaning. The purpose of the de-superheaters is to provide for harbour conditions when the greater part of the steam is used for running the saturated-steam auxiliary services. Under these conditions, it is necessary to protect the superheaters from overheating and by fitting the de-superheaters, the whole of the steam output from each boiler is passed through the superheater tubes, but the unwanted superheat is subsequently transferred to the water in the drum as the steam passes to the saturated-steam stop valve.

The furnace walls are lined with standard-pattern firebricks bolted individually to the boiler casing panels, while the furnace floors are covered by two layers of standard unbolted firebricks, which are arranged in oil-tight trays so as to prevent fuel oil from leaking into the air ducts. An air heater of the tubular type is fitted to each boiler, that for the port boiler being visible in Fig. 2. The heaters are arranged so that the products of combustion pass through the tubes; the total heating surface of each air heater is 1,427 sq. ft. The two boilers are arranged within a closed stokehold, and the combustion air is supplied by two turbo-driven fans manufactured by Messrs. W. H. Allen, Sons and Company, Limited, each of which can deliver 15,000 cub. ft. of air per minute at 6 in. water gauge. The air enters the heaters at the back of the boilers and a division plate in each heater causes the air to pass between the tubes twice. The heated air is led to the oil-burning units through steel trunks which pass down the rear casings to the undersides of the boilers and finally into the air boxes fitted to the fronts of the boilers. A hinged baffle plate is fitted in each air duct so that, when required, the ducts may be rendered inoperative.

Each boiler is fitted with five oil burners of Messrs. Thornycroft's own design and manufacture. A view of one of the furnace fronts showing the burners in position is given in the photograph reproduced in Fig. 10, on page 156, while Fig. 3, opposite, is a sectional plan through the three bottom burners of the port boiler. It will be seen from these two illustrations that the furnace front plates are shaped so that the burners are directed towards the middle of the combustion space. The units are capable of burning standard or heavy grades of fuel oil at pressures ranging from 100 to 200 lb. per square inch within a temperature range of 150 to 200 deg. F. The oil sprayers are of the pressure type and the whirling chambers are designed to produce a fine spray issuin at an included angle of approximately 85 deg. The combustion air is admitted through a series of openings

round the burners, each set of openings being controlled individually by a hand lever fitted to the top of the burner; some of the hand levers can be seen in Fig. 10. The air doors are arranged to produce a swirl at the point where the air meets the oil spray, while a small quantity of air, having axial motion only, passes through slots formed in the deflector plate and serves to produce a primary flame for the ignition of the main flame.

Most of the auxiliaries associated with the main propelling machinery are of the steam-reciprocating type and were supplied by Messrs. G. and J. Weir, Limited, but a small number of Drysdale rotary pumps have been fitted for such services as fresh water and sanitation. Direct current at 230 volts is supplied by a 160-kW self-contained turbo-generator manufactured by Messrs. W. H. Allen, Sons and Company, Limited, and two 125-kW Diesel sets, the engines of which were supplied by Messrs. Mirrlees, Bickerton and Day, Limited, and the generators by Messrs. Mawdsleys, Limited. The turbine of the turbo-generator set runs at 8,500 r.p.m., which is reduced by reduction gearing to 1,250 r.p.m. The set is equipped with its own condenser, which is used also as an auxiliary condenser when the vessel is in port; it is, therefore, larger than required for the turbine alone. The two Diesel sets are five-cylinder, four-stroke machines and each develops 225 brake horse-power at 500 r.p.m. In addition to the main Diesel sets, a 25-kW set is installed in the engine room for harbour use; a similar set is located on the boat deck for emergency use. Other auxiliaries in the engine room include two Serck lubricating-oil coolers and a Sharples No. 5A Vaporite lubricating-oil purifier. In addition, there is a Diesel-driven air compressor, the engine of which was supplied by Messrs. R. A. Lister and Company, Limited, and the compressor by Messrs. The Hamworthy Engineering Company, Limited.

As previously mentioned, the vessel has accommodation for approximately 150 passengers in two classes. The first-class saloon, which is illustrated in Fig. 8, on page 156, is situated forward on the second deck and provides seating accommodation for all the first-class passengers at a single sitting. Outside the dining saloon, a stairway leads to a vestibule on the upper deck, which has been arranged to accommodate the first-class passengers, mostly in single- and two-berth cabins, but there are some four-berth cabins. A stairway from the vestibule on the upper deck gives access to the first-class lounge on the promenade deck and aft of the lounge there is a first-class combined smoke-room and bar. Double doors at the after end of the smoke room open on to a sports deck where there is an open swimming pool. Four de-luxe cabins, each having a private bathroom, have been arranged in a house at the after end of the boat deck, and the furnishing of these suites compares favourably with that found on modern liners. The accommodation for the second-class passengers has been arranged at the after end of the vessel. The dining saloon is in a deck-house at the after end of the upper deck, while the lounge and bar is situated on the poop deck. The first-class dining saloon, lounge and the de-luxe cabins are air conditioned, three Thermotank air-conditioning units having been installed for this purpose, while the remainder of the vessel is equipped with a Thermotank distribution and punkah-louvre system.

The navigational equipment of the vessel includes directional wireless, an echo sounder and a gyro-compass which controls an automatic helmsmen. A Hydrogap rudder is fitted and this is operated by an electro-hydraulic type steering gear controlled by telemotor from the helm. A public-address system has been installed throughout the ship. A feature of the system is that instructions issued from the bridge to the forecastle, poop and engine room can be acknowledged merely by speaking towards the loud-speakers from any distance up to 15 ft.

The designed service speed of the El Malek Foad is 18 knots, but it may be noted that during the full-power trials, six runs were carried out over a measured course during which the vessel attained an average speed of 20·54 knots, with a mean output of 7,927 shaft horse-power. The duration of the full-power trials was four hours, and for this period the fuel consumption was 0·781 lb. per shaft horse-power per hour, with a saturated-steam pressure of 294 lb. a square inch gauge, a steam temperature, measured at the boiler stop valves, of 690 deg. F., and a vacuum, measured at the condenser inlet, of 28·7 in. The mean output over the four-hour period was 7,992 shaft horse-power, and the mean propeller speed 252·7 r.p.m., while the mean displacement was 3,149 tons and the sea temperature 57 deg. F.

INSTITUTE OF TRANSPORT.—The Western Section of the Institute of Transport has formed a Graduate and Student Society at Bristol. Miss G. G. Chambers, 7, Whatley-road, Bristol 8, has been appointed honorary secretary.

BRITISH STANDARD SPECIFICATIONS.

THE following publications have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Ventilation.—The Codes of Practice Committee for Civil Engineering, Public Works and Building, which operates under the ægis of the Ministry of Works, have issued Chapter I (c) of the "Code of Functional Requirements of Buildings," as a draft for comment. The draft is concerned with "Ventilation" and supersedes the interim Chapter I (c) C.P. 6 : 1945, which covered ventilation only in relation to houses and flats. The present draft prescribes the requirements of ventilation for various types of building in relation to their use. Tables giving the rates at which fresh air should be supplied for factories, houses and flats, hospitals, offices, schools and other places of public assembly, are included. The conditions for which natural or mechanical ventilation is suitable are considered in detail. For natural ventilation an equation is given to determine the flow of air in relation to window area, wind speed and a coefficient of effectiveness determined according to certain conditions. The value of wall ventilators and flues is discussed and systems of mechanical ventilation are reviewed and recommendations made regarding their use. Comments received up till February 29 will be examined by a Co-ordinating Committee, who will submit a final draft for the approval of the Codes of Practice Committee. [Copies of the draft code, reference No. C.P. (B) 702, cost 2*s.*, postage included.]

Hand-Power Lifts.—A second draft code, issued by the Codes of Practice Committee, No. 407.301, covers hand-power lifts for passengers, goods and service. The code was prepared by a committee convened by the Institution of Mechanical Engineers on behalf of the Codes of Practice Committee. It discusses matters to be considered in respect of installation, siting and design and gives guidance on the information which should be exchanged before the building, which is to include a lift, is constructed. Specific recommendations regarding contract load, landing gates and method of operation are made. Typical examples are illustrated by means of diagrams and a specimen data sheet, which might form the basis of any inquiry and tender is included. Comments received up till March 2 will be examined by a Code and Drafting Committee and the final draft will be submitted by the Engineering Services Sectional Committee for the approval of the Codes of Practice Committee. [The price of copies of this draft code, reference No. C.P. (B) 706, is 2*s.*, postage included.]

BOOKS RECEIVED.

Second Year Engineering Science. Mechanical. By G. W. BIRD. Revised by STRUAN A. ROBERTSON. Third edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 8*s.* 6*d.* net.]

Garcke's Manual of Electrical Undertakings and Directory of Officials. 1947-1948 edition. Compiled under the supervision of FREDERICK C. GARRETT. Electrical Press, Limited, 23, Great Queen-street, London, W.C.2. [Price 63*s.* net.]

The British Corporation Register of Shipping and Aircraft. Register of Ships. 1947-48. The Secretary, Offices of the Corporation, 14, Blythswood-square, Glasgow, C.2. [By subscription, 6*l.* 6*s.* 0*d.* and 8*l.* 8*s.* 0*d.*]

Industrial Applications of Infra-red. By JAMES DOYLE HALL. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 3.50 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 21*s.*]

Starting a Small Machine Shop. By FRED H. COLVIN. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 2.50 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 15*s.*]

Introduction to Modern Physics. By the late PROFESSOR F. K. RICHTMYER and PROFESSOR E. H. KENNARD. Fourth edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 6 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 36*s.*]

Department of Scientific and Industrial Research. Report of the Geological Survey Board for the Year 1945. With a Note on the Work of the Geological Survey and Museum During the Years 1939 to 1944. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 9*d.* net.]

The Scientific Instrument Manufacturers' Association of Great Britain, Limited. Handbook, 1947. Offices of the Association, 26, Russell-square, London, W.C.1. [Price 10*s.* 6*d.*, post free.]

PERSONAL.

DR. F. H. TODD, B.Sc., M.I.N.A., who joined the staff of the William Froude Tank in 1928, has resigned his appointment as Principal Scientific Officer, Ship Division, National Physical Laboratory, to take up the post of chief naval architect to the Hydromechanics Division of the David W. Taylor Model Basin, Washington.

MR. G. H. FLETCHER, M.I.E.E., M.I.Mech.E., chief engineer and manager of the Metropolitan-Vickers Attercliffe Common Works, Sheffield, has been appointed to the board of the Metropolitan-Vickers Electrical Export Company, Limited.

MR. J. W. THOMAS, B.Sc., LL.B., M.I.E.E., who has been secretary of the British Engineers' Association for the past three years has been appointed chief education and training officer, British Electricity Authority, Portland-court, 170A, Great Portland-street, London, W.1.

DR. D. W. PHILLIPS, who joined the staff of the Safety in Mines Research Board laboratories, Sheffield, 15 years ago and has been principal scientific officer for the past two years, has been appointed chief safety engineer, National Coal Board, London.

MR. HUGH R. NEILSON and MR. IAIN M. STEWART have joined the board of directors of Messrs. Glenfield and Kennedy, Limited, Kilmarnock, Ayrshire.

MR. DENIS REBBECK, M.A., M.Sc., MR. D. H. ALEXANDER, O.B.E., M.Sc., and PROFESSOR A. H. NAYLOR, M.Sc., M.I.C.E., have been elected members of the Council of Scientific Research and Development formed recently by the Ministry of Commerce of Northern Ireland.

MR. HENRY HOAD, M.I.Mech.E., has relinquished his appointment as Chief Controller, Mechanical Engineering Branch, Control Commission for Germany, and has taken up the appointment of Diesel contracts manager with Messrs. Davey, Paxman and Company, Limited, Colchester.

MR. H. P. POTTS, M.I.Mech.E., has resigned from the board of Messrs. A. A. Jones and Shipman, Limited, Leicester, in order to take up the appointment of managing director of British Engineers' Small Tools and Equipment Company, Limited (BESTEC), Buckingham House, Buckingham-street, London, W.C.2. MR. E. J. TOWNSEND has been appointed to succeed to the position vacated by Mr. Potts with Messrs. Jones and Shipman.

MR. JOSEPH WALTON, an assistant managing director of Messrs. Thos. W. Ward, Limited, Albion Works, Sheffield, has been appointed chairman and managing director of the Darlington Railway Plant and Foundry Company, Limited. MR. P. T. WARD has been made a director of the Darlington Company.

MR. J. P. D. COLEMAN, who has been works director, Wild-Barfield Electric Furnaces, Limited, Elecfurn Works, Watford By-Pass, Watford, Hertfordshire, since 1933, has retired from the board and also from that of their associated company, Messrs. G.W.B. Electric Furnaces, Limited, which he joined in 1938.

MR. J. L. MUSGRAVE is retiring from the joint managing directorship of the Richard Crittall group of companies, but will continue to serve as chairman. MR. A. E. HINDS, hitherto joint managing director, has been appointed managing director. MR. C. J. HYDE-TRUTCH has been made joint assistant managing director in control of sales and technical administration and MR. W. A. MCPHAIL, joint assistant managing director in control of financial, secretarial and general administration. MR. R. G. B. CRITTALL has been appointed general manager, southern area, and MR. J. P. HAMILL, general manager, northern area, Richard Crittall and Company, Limited. MR. W. R. COX has been appointed director and chief design engineer to the firm.

MR. R. CECIL SMART, M.C., M.I.Min.E., A.M.I.Mech.E., has been awarded the Nursey Premium of the Society of Engineers for his paper, "Industrial Organisation as a Factor in Productive Efficiency."

Arrangements have been concluded between the FAIREY AVIATION COMPANY, LIMITED, Hayes, Middlesex, and the CLYDE ENGINEERING COMPANY, of Sydney, New South Wales, Australia, which will lead to the formation of FAIREY-CLYDE AVIATION PTY. LIMITED, Sydney.

THE NORTHERN ALUMINIUM COMPANY, LIMITED, have moved their Birmingham sales office to 14, Temple-street, Birmingham, 2, and their south-western area sales office to 18, St. Augustine-parade, City Centre, Bristol, 1.

The Council of the Institution of Production Engineers have appointed MR. T. B. WORTH, A.M.I.Mech.E., M.I.P.E., to be Education Officer of the Institution.

The British Electricity Authority announce that Mr. L. J. LUFFINGHAM, editor of the *Electrical Times*, has been appointed Public Relations Officer, with MR. W. J. HENDRY and MR. G. G. MCKENZIE as his deputies. Mr. Hendry has been Press Liaison Officer of the Central Electricity Board since 1933 and Mr. McKenzie was Director of the Information Office, British Embassy, Washington.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—A strike of 'bus operatives which began with the suspension of services at a few depots in the West of Scotland on January 26, and gradually spread across the central part of the country until some 5,000 employees were involved, caused much less disruption in the industrial belt than had been feared. Steelworkers showed commendable enterprise in finding alternative transportation to and from their place of employment. No serious loss of working time occurred, and steel production was maintained at the recent satisfactory level. Raw-material supplies have been forthcoming regularly in time to keep plants operating continuously, although deliveries of scrap have not improved sufficiently to permit of other than hand-to-mouth charging of the melting furnaces. Pig-iron production at Messrs. Colvilles' works has had rather a set-back, due, it is understood, to unsuitable coke in supplementary deliveries from the South, together with technical difficulties arising out of the link-up of the new blast-furnace with the two older units. Scottish steelmakers have been receiving numerous inquiries regarding tonnages and prices from many countries, including some in the hard-currency areas. Considerable tonnages have been earmarked for export to some of the latter, notably Argentina. Scottish steelmakers are watching carefully developments in regard to French steel export prices, since the devaluation of the franc. The general consensus of opinion at this stage is that the sharp reduction in export prices has not yet created a position that can be regarded as constituting a major threat to United Kingdom exporters.

Scottish Coal.—The curtailment of 'bus services caused more inconvenience to miners than to any other group of workers, but output losses were held at a relatively low figure as a result of emergency transport measures put into execution largely by the N.C.B., and partly by the 'bus companies. The Central East and Central West Areas of the Lanarkshire coalfield were particularly affected by the strikes, and a few thousand tons were lost in a week. Production in Ayrshire was less interrupted, the loss amounting to several hundred tons a week. The reduced output in Lanarkshire was aggravated by stoppages at one or two collieries. Less essential users held adequate stocks to offset the shortages in deliveries, and industrial production generally was not interfered with. Gasworks, electric power stations, steelworks, and coke-ovens have been receiving their allocated tonnages. Large coal continued short of requirements, but domestic deliveries were only slightly below the programme after railway tonnages had been provided. Exports have been moving steadily from Scotland, the major portion of recent shipments having gone to Sweden, which now has had over 34,000 tons from Fife since exports were resumed.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—The failure of outputs to show a recovery following the Christmas setback has caused some concern in shipping circles in South Wales during the past week. The latest figures available showed a reduction in the amount of saleable coal raised at the mines to 435,200 tons in the week ended January 31, compared with 441,065 tons in the preceding week. This was the lowest point reached in any normal week since the beginning of November last. One of the chief causes of the decline has been the refusal of the miners to work the voluntary Saturday morning shift. In the last Saturday for which figures were available, the output amounted to only 11,253 tons, compared with over 40,000 tons reached towards the end of last year. It was upon the increase due to the Saturday shift that the Government agreed on the quantity of coal to be shipped overseas this year. In the past week, further business has been arranged for the Argentine, bringing the total number of cargoes for the month of February up to five, with a total of 35,000 to 40,000 tons. It is generally believed that the two Governments had agreed upon a coal-shipping programme in return for food, but the amount of coal involved is still conjectural. When trade negotiations were proceeding it was announced that agreement had been reached for the early resumption of coal deliveries, and the figure of 1,000,000 tons per annum was mentioned. The Argentine has always been an important customer for Welsh coals, taking about 2,000,000 tons a year in the pre-war years. The supply position has been very difficult in the Welsh steam-coal market throughout the past week. Inland consumers continued to make very heavy demands and accounted for the bulk of the outputs. Orders already in hand from this source were sufficient to absorb the potential outputs over the next month or so. The amount of coal available for shipment was insufficient to enable shippers to cover all requirements. The demand for cokes and patent fuel is still heavy and exceeds available supplies.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—While the production of basic steel is increasing a little and satisfies the demand, that of high-carbon steels, high-speed and stainless steels, falls short of requirements. There is a scarcity of raw materials; a little more pig iron is available, but not enough to offset the big demand in the absence of adequate supplies of scrap for re-melting. At one leading works, scrap material from a dismantled North Lincolnshire steelworks is being used for furnace charges. The very heavy demands for iron and steel works plant and machinery is only partly satisfied. Many national orders are on the books in Sheffield, and works are being extended to secure earlier delivery. Good progress is being made with the scheme of Messrs. Davy and United Engineering Company, Limited, to re-organise and re-equip their two works in Sheffield and that at Glasgow. At the Darnall Works a new erecting shop, 420 ft. long by 90 ft. wide, is partly in use; the old erecting shop is to be re-equipped as an additional machine shop and the iron foundry is being modernised. At the Park Iron Works of the company a new smiths' shop is to be installed and there is to be extensive replacement of machine tools. The production of mining machinery and equipment is being speeded up. The hot- and cold-rolled strip mills are actively engaged, and wire rods are being rolled on a large scale. Makers of wire ropes are very busily employed.

South Yorkshire Coal Trade.—Disappointment at the results of Saturday morning work at the pits has led to decisions to abandon such work at some pits, where absenteeism has been so high that it is not economical to open the pits on Saturdays. Stocks of coal are fairly satisfactory; much greater than they were a year ago. Locomotive hards are in fair supply. Gas coal is in strong demand to permit the building up of reserves after the very heavy consumption of the past six or seven weeks. Supplies of coal at electric generating stations are satisfactory. The make of hard coke is being increased a little. House coal is in better supply.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Tees-side iron and steel producing plants continue to operate at as high pressure as conditions permit but the heavy aggregate tonnage output is still below the urgent requirements of home and overseas customers. The demand for larger deliveries of pig iron continues. The make of Cleveland No. 3 was discontinued some time ago and there seems to be little likelihood of a resumption of the production of that commodity. The manufacture in the Middlesbrough area of pig iron suitable for foundry use, is intermittent and trifling with a fixed market value of £9 9*s.* 9*d.* less 5*s.* rebate, or only 15*s.* 3*d.* per ton below the highest recorded figure of 10*l.* 5*s.* for No. 3 g.m.b. Cleveland pig realised in 1920. The present figure represents an increase of over 100 per cent. in comparison with the 1937 price, whereas the general level of iron and steel quotations is not more than 60 to 70 per cent. above pre-war values. The inadequate supplies of iron and steel scrap continue to cause anxiety. The demand for the various classes of steel remains at a much greater level than producers can provide.

Foundry and Basic Iron.—As the make of the substitute for foundry iron in the Middlesbrough district is meagre and unlikely to be greatly increased, North-East Coast founders are obliged to draw pig iron extensively from the Midlands and other distant iron centres, under such conditions, irregular and inadequate delivery is unavoidable. A hematite furnace has been changed to the production of basic iron, the output of which is only sufficient for the essential needs of the local consuming plants.

Hematite, Low-Phosphorus and Refined Iron.—The distributable tonnage of hematite is moving promptly into use, the outputs of low- and medium-phosphorus grades of iron are steadily absorbed, and the make of refined qualities is taken up readily.

Manufactured Iron and Steel.—Semi-finished and finished iron manufacturers are turning out large quantities of commodities for their customers' urgent requirements and the producers of all classes of steel have heavy delivery obligations. Parcels of steel semies reaching the re-rolling mills are on a slightly better scale than of late, but still fall considerably below requirements and the shortage prevents some mills from operating at the full capacity limit. Billets, blooms and sheet bars are wanted in much larger quantities than are available; the anticipated better supplies from overseas are not yet coming forward. Plate producers, sheet makers and joist manufacturers are actively engaged, and the bookings for railway requisites and colliery equipment are extremely heavy.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Mersey Centre:* Monday, February 16, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "Design of Disc-Recording Equipment," by Mr. H. Davies. *Scottish Centre:* Wednesday, February 18, 6 p.m., Heriot-Watt College, Edinburgh. "Oil Deterioration in Transformers and Switchgear," by Mr. H. Hurworth. *North-Eastern Centre:* Wednesday, February 18, 6.15 p.m., Literary and Philosophical Society, Newcastle-upon-Tyne. Faraday Lecture on "Electricity and Everyman," by Dr. P. Dunsheath. *Institution:* Thursday, February 19, 5.30 p.m., Victoria-embankment, W.C.2. "Vertical-Shaft Water-Turbine-Driven A.C. Generators," by Messrs. E. M. Johnson and C. P. Holder. *Measurements Section:* Friday, February 20, 5.30 p.m., Victoria-embankment, W.C.2. "Absolute Measurement of High Voltages by Oscillating-Electrode Systems," by Dr. E. Bradshaw.

JUNIOR INSTITUTION OF ENGINEERS.—*North-Western Section:* Monday, February 16, 7 p.m., 16, St. Mary's Parsonage, Manchester. "Modern High-Pressure Steam Boilers," by Mr. G. Cooke. *Institution:* Friday, February 20, 6.30 p.m., 39, Victoria-street, S.W.1. "Ferranti and His Engine Designs," by Mr. W. E. Wyatt Millington.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 17, 5.30 p.m., Great George-street, S.W.1. "Tidal Power: Its Development and Utilisation," by Mr. B. D. Richards. *Birmingham Association:* Thursday, February 19, 7 p.m., Loughborough College, Loughborough. "Hydro-Electric Development and the Scottish Highlands," by Mr. N. J. Cochrane.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, February 17, 6.15 p.m., 2, Savoy-hill, W.C.2. "Critical Temperature Control in Domestic and Industrial Processes," by Mr. F. E. Butcher.

INSTITUTION OF THE RUBBER INDUSTRY.—*London Section:* Tuesday, February 17, 7 p.m., Caxton Hall, Victoria-street, S.W.1. Brains Trust on "Latex."

INSTITUTION OF STRUCTURAL ENGINEERS.—*Yorkshire Branch:* Wednesday, February 18, 6.30 p.m., Great Northern Hotel, Leeds. "Timber Construction," by Mr. E. H. Nevard.

INSTITUTE OF WELDING.—*West of Scotland Branch:* Wednesday, February 18, 6.45 p.m., 39, Elmbank-crescent, Glasgow. "Welding for Dredge Construction," by Mr. D. W. Low.

INSTITUTION OF PRODUCTION ENGINEERS.—*Birmingham Section:* Wednesday, February 18, 7 p.m., James Watt Institute, Birmingham. "British and American Industrial Efficiency," by Mr. L. C. Ord. *Western Section:* Wednesday, February 18, 7.15 p.m., Grand Hotel, Bristol. "Manufacture of Ball and Roller Bearings," by Mr. R. L. Tardy. *Glasgow Section:* Thursday, February 19, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Drop Forging," by Mr. J. D. Latta.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, February 19, 2.30 p.m., Caxton Hall, Victoria-street, S.W.1. Discussion on "Users' Operating Problems."

INSTITUTION OF MINING AND METALLURGY.—Thursday, February 19, 5 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Economic Recovery of Minute Quantities of Gold from Lead-Silver Bullion," by Mr. Walter Frayne. "Labour Organisation at the Badhia Mine, India," by Mr. A. L. Austen.

SOCIÉTÉ DES INGÉNIEURS CIVILS DE FRANCE (BRITISH SECTION).—Thursday, February 19, 5.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Reconstruction of Railway Bridges in France," by Mr. L. Carpentier.

INSTITUTION OF MECHANICAL ENGINEERS.—*Midland Branch:* Thursday, February 19, 6 p.m., James Watt Institute, Birmingham. "Seamless Steel Tubes," by Dr. J. W. Jenkin. *Scottish Branch:* Thursday, February 19, 7.30 p.m., Royal Technical College, Glasgow. James Clayton Lecture, by Sir E. Bertram Rowcroft. *Institution:* Friday, February 20, 5.30 p.m., Storey's-gate, S.W.1. With INSTITUTION OF ELECTRICAL ENGINEERS. "Corrosion of Heating Surfaces in Boiler Plants," by Messrs. J. R. Rylands and J. R. Jenkinson. AUTOMOBILE DIVISION. *Scottish Centre:* Monday, February 16, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Springs for Automobile Suspension," by Mr. B. Mackenzie. *Western Centre:* Thursday, February 19, 6.45 p.m., Grand Hotel, Bristol. "Public Service Vehicles," by Mr. D. M. Sinclair.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, February 20, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "Vibration Records and Similar Traces in Engineering," by Mr. R. G. Manley. "Ship Vibration," by Dr. F. H. Todd and Mr. W. J. Marwood.

KHEDIVIAL MAIL LINE PASSENGER STEAMER "EL MALEK FOAD."

MESSRS. JOHN I. THORNYCROFT AND COMPANY, LIMITED, LONDON.

(*For Description, see Page* 152.)

FIG. 8. FIRST-CLASS DINING SALOON.

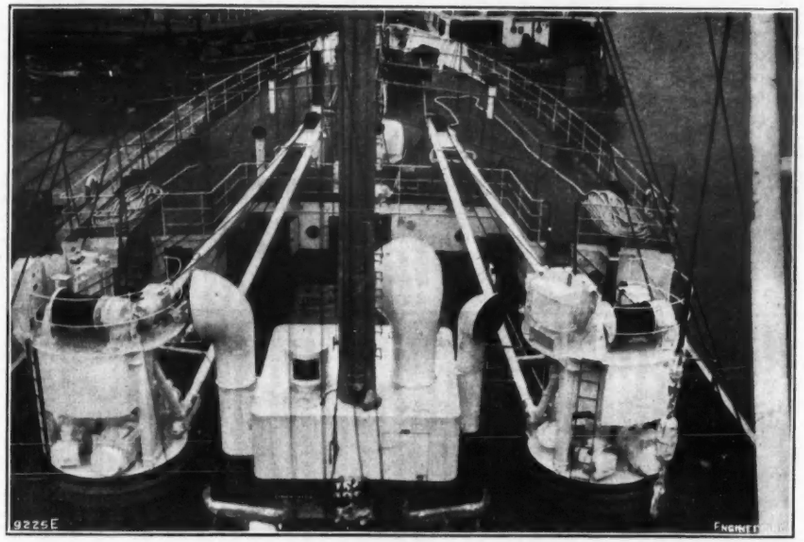


FIG. 9. ELECTRIC CRANES FOR NO. 1 HOLD.

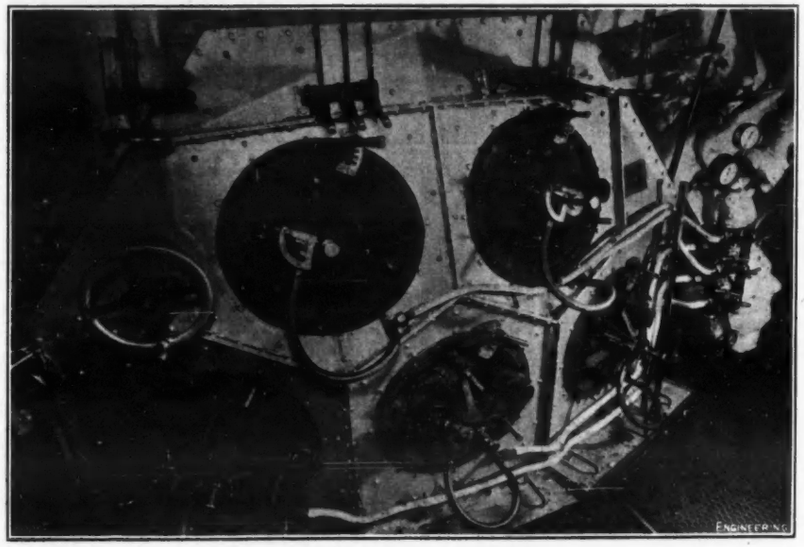


FIG. 10. FURNACE FRONT AND OIL BURNERS.

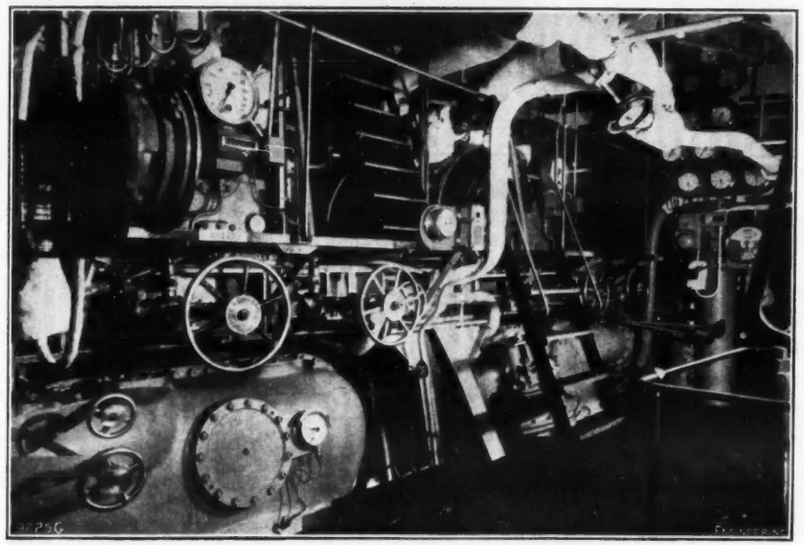


FIG. 11. ENGINE-ROOM CONTROL PLATFORM.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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THE CAUSES OF ELECTRICAL ACCIDENTS.

THE report on "Electrical Accidents and Their Causes," which has been prepared by H.M. Electrical Inspector of Factories for the year 1946, and has been published by H.M. Stationery Office (Price 9*d.* net), discloses a state of affairs which on the whole may be considered satisfactory. The number of accidents reportable under the Factories Act during the period under review, *i.e.*, those involving disablement for more than three days, was 769, of which 33 were fatal. In addition, there were 62 non-reportable accidents, of which 16 were fatal; and 98 fatalities in places other than factory premises. The total known fatalities, therefore, amounted to 147, compared with 178 in 1945 and an average of 167 annually during the period 1942-46. It is not altogether surprising to learn that a large proportion of all these accidents occurred on domestic premises, nor that most of them were due to the use of portable electric heaters. Mishaps of this kind are likely to persist so long as the design and manufacture of this apparatus is not brought under some control; and until the uninstructed public becomes aware of the risks that are attendant on its employment. It is, therefore, a little unfortunate that only passing reference can be made in the report to these accidents (since the inspectors are only concerned with factories), as some discussion of the causes underlying them would be instructive both to manufacturers and users, and might do much to stimulate improvement.

As it is, the analysis of accidents, which is given in the report, is confined to reportable accidents in relation to employment. It shows that although the figures have not yet fallen to pre-war level, the downward trend is continuing. This is the more satisfactory since the output of electricity continues to increase, if at less than the pre-war rate. On the other hand, the small, but steady, rise in the number of accidents occurring to electrically skilled persons still continues. That this is correctly ascribed to carelessness and over-confidence is clear from the detailed accounts of certain accidents that are given. It is, of course, easy to prescribe a remedy, but more difficult, while human nature remains what it is, to ensure that that remedy will be invariably applied.

While the 33 fatal reportable accidents were spread fairly evenly over all classes of apparatus, with switchgear above 650 volts as the principal offender, it is interesting to note that of the 736 non-fatal accidents, no less than 161 were in the form of eye injuries incurred during electric welding. The number of accidents associated with portable electric tools and their flexible cables was 157 and, though this compares with 207 in the previous year, it still forms too high a proportion of the total, especially when it is remembered that accidents of this type are likely to be much more serious than those associated with electric welding. An examination of 57 accidents, which occurred in a particular area, shows that in 24 of them misuse, negligence or ignorance were the pre-disposing causes; and faulty installation or maintenance in another 19. Design was responsible in only five cases.

Figures such as these, however, are insufficient in themselves to provide data upon which future improvement can be based. On the other hand, much can be learnt from the conditions, human and material, prevailing at the time of the accident. The analysis of the evidence often discloses a great deal of useful information regarding the weaknesses of present design and practice, the correction of which should assist in stimulating further progress. For that reason the descriptions of certain typical accidents and occurrences must be regarded as a valuable portion of the report, and the same is true of the analysis of conditions which, owing to the increasing use of electricity for all purposes, may give rise to actual or potential danger.

One of the most important of these conditions is that involved in the protection of the equipment and of the personnel controlling it. An example of the need for the constant exercise of vigilance in this respect is provided by the fact that the increasing load on distribution systems has led, in many cases, to the "stiffening" of fuses in the section pillars; and sometimes to their replacement on individual distributors by links. The result has been a solid network supplied from one or more substations. It is rightly pointed out that with such an arrangement a fault in the service termination of a factory may be "thrown back" on to the transformer circuit-breakers at the substation. In one case the incidence of a fault under these conditions caused a 300-ampere three-phase service cut-out box to be disintegrated by an energy flow of some 12,500 kVA, with fatal results, while the fault itself was only cleared by the network interconnecting fuses and the transformer circuit-breakers. The adequate protection of the small motors, which are being increasingly used in the textile industry, provides a similar problem. These motors are of the three-phase type with a rating of 70/80 watts; and, as they are required to run at 6,000 r.p.m., are generally supplied with current at 80 volts and a frequency of 100 cycles per second. While, therefore, the full-load current is about 0·75 ampere, the starting current may be 5 to 15 times this value during a period of 40 to 45 seconds; and the same value may be reached when the motors are reversed to reduce the stopping time. Moreover, as plant of this character operates in an extremely corrosive atmosphere, there has been a tendency to reduce the amount of control gear to a minimum, to employ the least possible amount of copper in its construction, and to arrange the motors in groups so as to cut down the number of fuses. In fact, as many as 18 motors have been found grouped on one set of fuses, the result, obviously, being that little protection is provided for individual machines. The effect of a fault is, therefore, a complete burn out; and in one factory, where 3,000 of these motors are installed, this by no means venial type of casualty has been occurring at the rate of no less than 14 a day. Maintenance and repairs are consequently serious items, to mitigate which, special forms of fuses are being tested. If for no reason, other than economic, this is clearly a matter which must be pursued farther.

The connection of the non-current-carrying parts of electrical equipment to earth is a practice enjoined by the regulations and, in spite of some opinion to the contrary, probably commands general acceptance. For it to be effective, however, the earth connection must be adequate for the condi-

tions present and must be properly maintained; otherwise the protection afforded is illusory and the risk of accident correspondingly great. For instance, it can no longer be assumed that a good connection to a metal water service pipe will provide a sufficient earth, since the employment of non-metallic mains is increasing; and there is apparently no obligation to notify their installation. The regular testing of the earth fault loop circuit impedance by the consumer and the electricity supply undertaking in association is therefore necessary to ensure safety.

Another facet of the same problem is that there may be a lack of co-ordination between the earth fault circuit impedance and the fusing current or over current settings of the protective apparatus, with the result that a persistent leakage to earth occurs. In fact, the protective gear may be rendered ineffective for this reason, as is shown by the case of a machine which was considered to be protected by an oil circuit-breaker, the overload trips of which were set at 148 amperes. The fault circuit impedance, however, was found to be 8·5 ohms, so that the maximum earth-fault current was only 27 amperes, thus rendering the protection inoperative, even when conditions became dangerous. Tests on a group of installations in an urban area also disclosed that although 86 per cent. had fault-circuit impedances of less than 2 ohms, in 54 per cent. of them the protective apparatus would have been ineffective, either because the value of the earth-fault current necessary to operate it would never have been reached or because those in charge were not in possession of the information necessary to determine whether it would work or not. Such conditions are less likely to occur on new installations than on those which have been extended without adequate planning. An example of this is provided by the case of a circuit feeding a 50-kVA transformer, which was "protected" only by a circuit-breaker with a setting of 1,095 amperes. The result was that a fire occurred, which wrecked the whole of the main switchgear and badly damaged the roof.

The design and maintenance of portable electric tools are among other matters which demand careful attention. Such tools are, of course, being increasingly used in such situations as foundries, dye works and tanneries, as well as inside boilers and on outdoor sites where, owing to wet conditions, the presence of large masses of metal and the severe usage to which the equipment is subjected, an electric shock may have serious consequences. It is therefore recommended that such equipment should be supplied at 100 to 110 volts through a transformer with the mid-point earthed, so that the maximum pressure to earth will not exceed 50 to 55 volts. It is also rightly pointed out that a regular and efficient maintenance service for large installations is necessary, and that the degree of safety would be increased by the employment of earth-leakage protective devices. That there is a good deal of justification for these recommendations is shown by the fact that, during 1945, about 42 per cent. of the fatal electrical accidents were in some way associated with portable electrical tools.

The increasing use of high-frequency currents for heating, often in association with high voltages, has recently introduced a new type of electrical accident. In spite of the fact that manufacturers have developed the apparatus with a recognition of the risks involved, and have provided interlocks to prevent access to parts which may be at dangerous pressures, there is too often a tendency to regard this equipment with an unjustified degree of familiarity. The result has been a number of cases of shocks and burns due to contact with live conductors, and sometimes the period of recovery has been abnormally slow. This raises the question of the effect of stray high-frequency fields on the human body. Although there is no evidence of any injury from this cause, it is obviously a matter which must be watched.

Although the number of accidents which arise from electrical causes is not large in proportion to the quality of this class of apparatus now in use, there is evidence to show that a reduction could be effected without a great deal of difficulty. It is therefore to be hoped that every effort will be made to bring this reduction about.

THE TENNESSEE VALLEY AUTHORITY.

THE Act establishing the Tennessee Valley Authority was passed in 1933. At that time, the uncontrolled Tennessee River at high flow contributed as much as 25 per cent. to disastrous floods on the Mississippi River, into which it flows, and in dry seasons shrank to such an extent that navigation on a commercial scale was impossible, the governing depth in the lower reaches being 4 ft., and in the higher 1½ ft. The Act set up a public corporation which, in the words of President Roosevelt, was "clothed with the power of government but possessed of the flexibility and initiative of private enterprise." The whole matter raised much controversy, particularly in connection with the electricity-supply industry in which the Authority was empowered to engage. Its main duties were flood control and the improvement of navigation facilities, electricity supply being in a sense incidental, but in the course of the fifteen years since its formation, the capacity of the Authority's electrical installation has grown to such an extent that in 1947 more power was produced by it than by any other integrated power system in the United States. Opposition to the electric supply powers conveyed in the Act was based on the contention that they permitted government-sponsored competition with private enterprise.

In the latest annual report of the Authority, which covers the year ended June 30, 1947, it is stated that in 1933 the average *per capita* income of the people of the Tennessee Valley was only 40 per cent. of the national average and that by 1945 it had risen to 58 per cent. This result may be attributed entirely to the work of the Authority, which has developed in many fields. Navigation has been improved to such an extent that a 630-mile artery for deep-water inland navigation has been provided and, in the first six months of 1947, 153 million ton-miles of freight moved on the river, this figure being exclusive of sand and gravel, which mainly represent the Authority's own traffic. The total was 25 per cent. greater than that of the first six months of 1945, which was the previous record year. Privately-owned terminal facilities constructed on the river are now estimated to represent an expenditure of two million dols.; there are five grain-handling terminals and eleven bulk-storage and oil-handling stations. As the main lock on the Kentucky Dam, was completed only two years ago, it is considered that the commercial development of river traffic is still in an early stage and that the 22,000 tons of miscellaneous freight handled at public wharfs should rise to 7 million tons in the next 15 years.

In 1947, for the second year in succession, the system of dams had to deal with what under the old regime would have been a major flood. Excessive rainfall and exceptionally high run-off in January caused a flood which, if uncontrolled, would have reached a stage of 44·5 ft. at Chattanooga, a gauging station lying rather more than half way up the river from the mouth. Control reduced the crest at this point by 12·7 ft., at Knoxville, on the upper reaches, by 9·3 ft., and at the Pickwick Landing Dam, the next dam on the river above the Kentucky Dam, by 4·5 ft. The average annual rainfall over the Tennessee Valley is 52 in., the wet season extending from late December to early April, and the waters have to be controlled with regard to three main statutory duties of the Authority, flood prevention, navigation improvement and the generation of electricity. At the beginning of the wet season in December, the reservoirs formed by the dams, having been run down during the summer and autumn, have a minimum capacity of 11 million acre-feet for the retention of floodwater. As the season progresses and the danger of floods diminishes the reservoirs are allowed to fill to some extent, but a capacity of some 10 million acre-feet is retained until all danger is past. When indications of the development of a flood are received from the 235 rainfall and stream-gauging stations in the gathering grounds, the spillway gates are set for rapid discharge, and it is stated that the water can be passed down the river under control even more rapidly than it would discharge under natural conditions. Towards the end of the wet season the reservoirs are allowed to fill to furnish supplies during the summer, but the main-stream reservoirs, except for that behind the Kentucky Dam, have little storage capacity. The main reserve is held in the tributary reservoirs. Under this regime, the hydro-electric plants are usually able to meet the power demand, but in 1947, in spite of the wet January with its potential flood, the latter part of the year was so dry that, towards the end, 18 per cent. of the load was being carried by the stand-by steam stations.

From an engineering point of view, the most striking feature of the Tennessee Valley development is the construction of the remarkable series of dams which have been built across the main river and its tributaries in the course of 13 years. A number of these have been described in these columns in the past. There are 16 new dams and ten others, mainly of smaller type, which previously existed and have been integrated into the single river-control system. Development is not yet complete, and, during the year, work was resumed on the Watauga and South Holston dams, which had been started in the early part of the war, but on which work was later stopped on instructions from the War Production Board. These dams are situated on tributary rivers on the confines of the gathering ground. They will add 1,287,000 acre-feet of water storage and will have installed hydro-electric plant of 85,000-kW capacity. In a critically dry year these dams will provide an additional power capacity of 110,000 kW, owing to improved supplies to the hydro-electric plants downstream.

The total capacity of the hydro-electric plants on June 30, 1947, was 2,088,702 kW; to this must be added 449,350 kW of steam plant and 850 kW of internal-combustion engine plant, making a total of 2,538,902 kW. The above figures include 311,120 kW capacity of hydro-electric plants of the Aluminum Company of America, which are operated under the direction of the Tennessee Valley Authority, and 20,000 kW of steam plant operated under contract with the Memphis Generating Company. The largest hydro-electric plant, of 335,200 kW, is situated at the Wilson Dam, and the largest steam plant, located at Watts Bar, is of 240,000 kW capacity. Projected additions, covering 14 new water-power units, will add 402,600 kW. These extensions are scheduled to come into operation by March, 1951, but include a 32,000-kW set at the Kentucky Dam, which has been completed since the date of the report. In the year covered, 14,797 million kWh were generated, compared with 12,314 million in 1946.

In addition to its activities in connection with river regulation and power supply, the Authority does much towards the rehabilitation and cultivation of the area with which it is concerned. In the past, there has been a considerable amount of soil erosion owing to unregulated cropping and unwise tree felling, and, in conjunction with the United States Department of Agriculture and State services, better methods are being introduced. During the period 1934-44, more than a million acres of the 11 million acres of agricultural land in the valley were changed over from row crops to close-growing grain and pasture in order to reduce run-off and erosion, and more than a million acres have been terraced, to the same end. More than half of the area of the Valley is wooded and the forests sustain an industry with an annual turnover of 100 million dollars. The wasteful exploitation of the past has been improved on and a proper regime of forest management introduced. The Authority provided 5,660,000 trees from its nurseries during the fiscal year 1947, and the plan for this year covers twice this number. An important activity in the agricultural programme has been the establishment of a plant for the manufacture of phosphates and the rehabilitation and re-starting of a nitrate plant which was built during the first world war. A further example of the value of the application of scientific methods is furnished by the results of the malaria control which has been introduced. In 1938, a survey of residents in the Valley showed that 10 per cent. gave evidence of malaria infection; for the last four years, surveys have indicated a low fraction of 1 per cent.

NOTES.

THE ELECTRICITY ACT, 1947.

SPEAKING in the House of Commons on Friday, February 6, the Minister of Fuel and Power (the Rt. Hon. H. T. N. Gaitskell) said that the vesting date of the Electricity Supply Act would be Thursday, April 1, 1948; and that he had made an Order to that effect. In this connection, it is announced that the Electricity Commissioners have had under review the factors which should govern applications involving capital expenditure on electrical equipment between now and the vesting date. It is pointed out that such applications often require the consent of the Treasury and the Public Works Loan Board, and therefore need time for approval. Moreover, any borrowing which has not been exercised at the vesting date will become inoperative. No useful purpose will, therefore, be served by making applications, unless there is reasonable likelihood that they will be exercised before the vesting date or are required as cover for entering into commitments, such as the placing of contracts, before that date. Although there must be no delay in the carrying out of essential electrical development, such development must also be considered in relation to the planning of the larger areas for which the Electricity Boards will be responsible after the vesting date. These bodies, therefore, must have an opportunity of considering proposals involving substantial expenditure. For these reasons all public electricity authorities are asked to refer future proposals for incurring expenditure in excess of 10,000*l.* to the appropriate Electricity Board before submitting them to the Electricity Commissioners for sanction. The Commissioners themselves will deal with such applications as are already before them on a similar basis and will limit any future sanctions to what would be regarded as the normal requirements of the undertaking up to September 30, 1948. This revised procedure does not apply to capital expenditure on generating stations and the grid; and the necessary consents required in connection with the National Plant Programme will continue to be issued as quickly as possible.

NAVAL MINING AND ANTI-SUBMARINE WEAPONS.

At a meeting of the Institution of Mechanical Engineers, held in London on Friday, February 6, with Dr. H. J. Gough, C.B., M.B.E., F.R.S., vice-president, in the chair, Dr. E. C. Wadlow, B.Sc., presented a paper on "Mechanical Engineering Aspects of Naval Mining," and Mr. J. M. Kirkby, M.A., presented a paper on "Some Mechanical Features in Anti-Submarine Weapons." The papers were well received, and many members and visitors took part in the discussion, most of them adding to the value of the papers by recalling their war-time experiences relating to the authors' subjects. Dr. Wadlow described German as well as British practice. There were two principal types of mines: "ground mines," resting on the sea-bed, and buoyant mines, moored to sinkers. The former were suitable for comparatively shallow water, and the latter for water of almost any depth up to about 1,000 fathoms. Ground mines laid by aircraft were used to a considerable extent during the recent war. The terminal velocity was controlled by a parachute, and generally restricted to between 200 and 250 ft. per second in British practice. The mine was prevented from continuing in the same line as its air trajectory, on entering the water, by chamfering its nose to an angle of about 20 deg. The mine was thus partly arrested before it hit the sea-bed. Dr. Wadlow then proceeded to describe the methods of laying mines from surface vessels and submarines, and the depth-taking arrangements with surface-laid and submarine-laid mines. He also considered the effect on design of the conditions pertaining after a mine has been laid, in particular, the effect of the tide, subsidence into mud, etc. Two other important considerations were "countermining"—to ensure that the explosion of a mine does not set off a nearby mine—and safety requirements. The latter were particularly important, and the author described the several methods of construction and precautions observed in use. The principles of firing systems, and the design of anti-sweeping features and other details were described in conclusion. Approximately 206,000 buoyant mines, and 57,000 ground mines had been laid by British ships and aircraft, and 1,588 enemy vessels had been sunk or severely damaged. Mr. Kirkby's paper dealt with anti-submarine weapons, principally depth charges dropped from the stern of a ship or from an aircraft, and "Hedgehog" projectiles discharged ahead of a ship. The depth charge, which has remained substantially unaltered in form since its introduction during the 1914-1918 war, consists of a steel cylinder, 18 in. diameter and 26 in. long, containing 300 lb. of explosive, and a central tube housing a firing mechanism which operates when a 50-ft. head of water has been built up in a primer tube. The disadvantage of dropping charges from the stern was the "blind" time from the moment when the Asdic beam no longer reported the position of the submarine to the instant of explosion of the charge at the required depth. The main factors in the problem were the angle of the Asdic beam, the position and subsequent movement of the submarine, the speed of the attacking vessel, the time of sinking, and the safety of the ship; and the author gave the quantitative relationships between these factors. The "Hedgehog" system of firing 62-lb. projectiles in a salvo ahead of the ship was developed during the war to overcome the blind-time disadvantage of depth charges. Although only the projectiles which hit the submarine were caused to explode, the probability of inflicting lethal damage was about three times greater than with depth charges. The author devoted considerable attention to weapon-discharge gears, since these have many features of engineering interest, and he described safety requirements, the effect of explosions, and depth charges from aircraft.

NATIONAL ADVISORY COUNCIL ON EDUCATION FOR INDUSTRY AND COMMERCE.

The Percy Report on Higher Technological Education recommended that what it termed a National Council of Technology should be set up to consider the national aspects of the work of the Regional Advisory Councils, some of which have been formed, and to advise the Minister of Education and the University Grants Committee on them. In view of this recommendation, the Minister of Education, in September, 1947, appointed a Working Party to report on the subject and make recommendations. The report (H.M. Stationery Office, price 2*d.* net) has now been published. It unanimously accepts the Percy recommendations and proposes the setting-up of a body carrying the somewhat long title which appears at the head of this note. The Council would be a deliberative and advisory body, the main function of which would be to advise the Minister of Education on the national aspects of regional policy. It is suggested that in its early stages the Council would probably be concerned mainly with advanced stages of education and would advise on all questions bearing on training for the professions, management and design in relation to industry; but it is added that the scope of its functions should not be limited as "technical and commercial education is a single whole from craftsmanship to management." The Percy Report proposed that the new body should be advisory to the University Grants Committee as well as to the Minister of Education, but this is not agreed to nor recommended. The University Grants Committee is itself the advisory body in its own special field and it does not seem likely that the proposed council, of more varied make-up, could act usefully in the matter with which the committee is concerned. It is recommended that the two bodies should keep closely in touch and, if it seems desirable, form a joint committee. A large membership is suggested for the Advisory Council, made up of five members from each Regional Advisory Council and seven from the London Region, the various members representing different interests, such as university institutions, teaching staffs, employers and employees; to these would be added members, up to a maximum of 20, nominated by the Minister. From this large body, it is proposed that a Standing Committee of 24 shall be chosen, Regional Councils, universities, teaching staff, employers and employees being represented on it. The duties of the Standing Committee are not defined, but presumably it will constitute the active body which will actually carry out most of the work of the Council. Assessors would be appointed by the Minister to attend the meetings, but not to vote.

THE WATER SUPPLY OF LIVERPOOL.

The water supply system of Liverpool, as a civil-engineering undertaking, first attracted general attention rather more than 50 years ago, when the Vyrnwy dam and reservoir were completed; at the time, Lake Vyrnwy was the largest artificial reservoir in Europe, and the dam was the first large structure of the kind in the British Isles to be built in masonry. The municipal supply system, however, is considerably older than the dam and, in 1947, attained its centenary; an event which has been marked by the publication of a commemorative brochure, tracing the history of the undertaking from the passing of the Liverpool Corporation Waterworks Act on July 22, 1847. There were earlier Acts, privately obtained, the earliest being in 1709; but the powers then conferred were not exercised, and it was not until 1786 that the Act was passed, under which an actual supply was provided in 1799. In the same year (1799) a waterworks company was formed, and another followed in 1822; but the supply was far from adequate and, in 1843, the city's Highway Commissioners decided to take action. Thomas Hawksley, as consulting engineer, prepared a scheme to bring water by gravity from Rivington Pike, in Lancashire, and this was the project that was put in hand under authority of the Act of 1847. The two water companies were bought out in the following year, and the Rivington works, begun in 1850, were completed in 1857. As the city expanded, the Rivington supply was found to be insufficient to meet the growing demand and, in 1876, a scheme was considered to construct a dam and reservoir in the valley of the Vyrnwy, in Montgomeryshire. It was adopted by the Council in 1879, the necessary Act was obtained in 1880, and work began in July, 1881. The first completed pipeline was formally brought into service on July 14, 1892, by H.R.H. the Duke of Connaught, although, in fact, Liverpool had then been receiving Vyrnwy water, through a temporary connection, for a year. A second pipeline was inaugurated by King George V (then Prince of Wales) in 1910 and a third in 1938. Work is now in hand on a fourth pipeline. During the hundred years covered by the survey, the consumption has increased from 3,100,000 gallons a day to nearly 45,000,000 gallons. The Vyrnwy dam, which contains more than half a million tons of masonry, is 1,172 ft. long and 144 ft. high from the foundation to the overflow level. The reservoir formed by it is 4¾ miles long and half a mile wide, and has a surface area, at the top water level, of 1,121 acres. The Rivington system now comprises eight reservoirs, having a total area of 598 acres and a total capacity of rather less than one third that of Lake Vyrnwy. Including compensation water and bulk supplies to various other municipal authorities, the Liverpool water-supply system provides an average daily output, for all purposes, of nearly 75 million gallons.

TRAINING COLLEGE FOR HYDRO-ELECTRIC WORK.

The North of Scotland Hydro-Electric Board is to establish a residential college at Pitlochry for training its technical staff. The site adjoins the new loch, which is to be formed by the Pitlochry dam, with Clunie power station at one end and Pitlochry station at the other. Ample residential and workshop facilities will be provided in two mansion houses and outbuildings. Further advantages of the site are that many of the larger generating stations are within easy reach; and that it will enable training to be carried out at a common centre. Professor S. Parker Smith is relinquishing the chair of electrical engineering at the Royal Technical College, Glasgow, to arrange and superintend the training scheme; and Mr. J. H. Cowan, lately senior lecturer on electrical engineering at the same institution, has been appointed Master of the new college. It is intended that on appointment the technical staff of the Board shall undergo a short training at the college before being

allocated to specific duties, and subsequently return for instruction and refresher courses as circumstances may require. Much of the instruction may be informal and on a "round table" or tutorial basis. The syllabus will be kept flexible; and it will be possible for students to perform operational duties at hydro-electric, steam and Diesel stations, to co-operate in the maintenance of transmission systems and to visit projects under construction and factories where new plant is being built. Lectures will be given on the Board's schemes, on the economic and communal life of the Highlands, and on future planning; and, as in the isolated areas it is essential that each member of the staff shall be mobile, instruction in driving and vehicle maintenance will form part of the practical work. It is felt that the college will also provide a valuable reserve pool of technical assistants who will be available in emergencies. The first of the Board's new projects will be in operation shortly and plans for opening the college are well advanced, so that recruiting will begin this year. Candidates must be in possession of approved educational and practical qualifications. In the case of engineers, a degree, diploma or Higher National Certificate with practical training, will be essential. Mechanics, electricians and other craftsmen will have to hold an Ordinary National Certificate and have served a trade apprenticeship.

The de Havilland "Ghost" Turbo-Jet Engine.

Among the many activities of the de Havilland group of companies is the development of their Ghost turbo-jet engine for use on the D.H.106, a projected pure-jet transport machine for use on the North Atlantic and other trunk routes. Endurance and fuel-consumption tests are being carried out on an Avro Lancastrian aircraft fitted with two Rolls-Royce Merlin engines inboard and two Ghost turbo-jet engines outboard, while data on high-altitude and high-speed aspects of engine performance are being obtained by one of the group's Vampire fighters in which a Ghost engine has been installed in place of the usual Goblin engine. Recently, Messrs. de Havilland announced that, during the course of normal development work, the latter aircraft attained an altitude of 56,000 ft. above sea level, which is only 61 ft. less than the official height record for heavier-than-air machines established by the Italian, Lt.-Colonel Mario Pezzi, in 1938, when flying a Caproni 161 machine. The Vampire was piloted by the company's chief test pilot, Mr. John Cunningham, and the photographic film of the automatic observer has now been developed and the reading of 56,000 ft. confirmed. Apart from the lack of armament and the fitting of a metal canopy and the non-standard engine, the aircraft is an ordinary fighter as delivered under Ministry of Supply contract to the Royal Air Force and also to the Canadian, Swedish and Swiss Air Forces. The height of 56,000 ft. was reached in 25 minutes in a climb from the ground at high forward speed and with a rate of ascent of approximately 110 ft. a second for the first 30,000 ft. For transport service, the Ghost engine is being developed to give a static-thrust rating of 5,000 lb., but the unit installed in the Vampire is an early-development engine having a test-bed rating of only 4,200 lb. thrust. In view of the practical results obtained, the Ministry of Supply and Messrs. de Havilland are investigating the possibilities of attacking the existing height record. To be accepted officially, a new record must exceed the old by at least 2 per cent., and while there is little doubt that this is within the capabilities of the aircraft, the attempt on the record must depend on the extent to which it might interfere with the development work in progress.

Jubilee of J. Samuel White and Company, Limited.—The shipbuilding business now known as J. Samuel White and Company, Limited, is one of the oldest in the country, having been founded by the original John White at Broadstairs in the Eighteenth Century. Between 1800 and 1810, it was transferred to Cowes, Isle of Wight, taking over Nye's shipyard, which had been on the Admiralty list of shipbuilders for more than a century. Under J. Samuel White, the yard became famous as builders of high-speed torpedo boats and destroyers, and, during the recent war, constructed the first all-welded destroyer, H.M.S. Contest. Fifty years ago, on February 8, 1898, the business became a limited company.

LETTERS TO THE EDITOR.

PROFESSIONAL SALARIES.

To the Editor of Engineering.

Sir,—I welcome the publicity given in your issue of January 30, page 110, to the "Charter for Technical Staff in the Engineering and Metallurgical Industries," produced by the Association of Scientific Workers, although I find your treatment disappointing. This Charter has appeared at a most appropriate time, as correspondence in your columns over recent months well testifies, and it is my hope that it will help to form the uneasy stirrings in the profession into some definite shape; at least that its proposals will stimulate serious discussion.

I desire to take up several points made in your review of the Charter, but, first, to state emphatically how encouraging it is to see at least one organisation endeavouring to solve the economic problems of the average engineer in industry, whatever criticism might be voiced of its proposals. In this context, I must point out the mutual contradiction between your third and fourth paragraphs. In one you state there appears yet to be no organisation taking steps in this direction. In the next, you say the Association of Scientific Workers is the latest body to attempt the problem. Certainly this Association is not specifically of, and for, engineers and metallurgists, but its membership in these fields is of the order of 10,000, which does qualify it to speak on their behalf. Further, even though this might not be a large percentage of the total, it is well spread over the various branches of engineering, so that the facts of salaries, conditions of employment, etc., brought to light by the various surveys the Association has conducted in preparation for the issue of the "Charter", are typical of the industry as a whole. Incidentally, some of the facts are staggering and well justify disillusioned people quitting the industry altogether for better remunerated occupations—often non-technical.

Your principal criticism of the "Charter" in regard to salaries is that scales—quoting the Burnham and Civil Service variety—impose rigid boundaries, equating the genius with the moron; although you go on to say, inconsistently, that the Charter's proposals are too flexible. But to deal with scales as such.

Professional workers are to-day becoming increasingly conscious of career prospects in their approach to specialisation. The great advantage of salary scales is that an individual contemplating entering a profession so covered, can see in advance what his prospects will be for the next 10 or 20 years, balance these against his possible domestic responsibilities and accept or reject as he chooses. Without scales the entrant launches himself on a complete sea of chance as far as his future is concerned. And it is not always a question of brilliance. Often the brilliant man is too engrossed in his work to agitate for increases in salary and such are seldom given in generous appreciation. Meantime the less brilliant man, but with vociferous campaigning or favour in the right quarter, outstrips him. Not everyone can become a chief engineer or a person of equivalent high status. There must always be a large bulk of "rank and file" workers wielding slide rules and plotting graphs, on whom the industry depends for its technical work. It is an indictment of the industry that, in general, these enjoy no better status (in terms of security of employment, social standing, etc.) than the average office boy or typist, even if their salaries be a little higher (but still inadequate and lacking in career value). Salary scales ensure that these people are not sacrificed on the altar of "every man for himself," which, it would seem, you advocate as the only principle which can cater for the occasional genius. This case for scales is, surely, very reasonable.

A very important qualification to the Charter's scales, overlooked in your review, is that they are specifically headed "Minimum." Thus there is nothing to prevent a man receiving a higher salary at any point in the scale if he can get it or his employer deems him worthy, but the scale itself takes care of the average man, giving a reasonable career prospect culminating in monthly status—the generally accepted mark of professional rank. This seems to me to be preferable to the present situation which is merely, for any given individual, the equilibrium between the minimum he will accept and the maximum the employer will pay. This gives rise to bad anomalies between individuals and it is significant that, when the Association has taken up such anomalies discovered in their surveys, adjustments of as much as 100*l.* per annum have been obtained: surely a confession by the particular employers that their methods of payment leave much to be desired.

Finally, a word as to the application of the scales and definition of the various grades. Your article has nothing better to offer as a solution to the problem than a continuance of the practice which has itself caused that problem. To quote: "In practice, the only person who can determine this matter is the employer. This is the present practice and he pays an adequate salary if he wants the work carried out properly because he has to." In other words, "There is no problem." I submit that the whole history of the trade union movement stands witness to refute utterly this highly contentious viewpoint. The questions of salary, correct grading, etc., will only be settled by negotiation and agreement with employers on trade union lines, as other sections of workers have solved their problems. This the Association of Scientific Workers alone is trying to do, and before taking final steps in this procedure it needs to secure as wide a measure of support as possible within the profession. I feel it to be a matter for regret that Engineering, which hitherto has appeared concerned about the very real problems facing the profession, should have been nothing but destructive in its attitude to the "Charter."

Yours faithfully,

I. K. Gough, B.Sc. (Eng.).

Manor Farm,
North Wick,
Dundry, Somerset.
February 4, 1948.

To the Editor of Engineering.

Sir,—In the editorial published on page 110 of your issue of January 30, in which is discussed the *Charter for Technical Staff in the Engineering and Metallurgical Industries* issued by the Association of Scientific Workers, a fundamental difference between the salary scales proposed for industry and those in operation for professional civil servants appears to have been missed. The scales for engineers proposed in the Charter are clearly stated to be minimum scales, and as such they have none of the rigidity of the salary arrangements for schoolmasters and civil servants. Brilliant and original men would certainly expect, and be able to command, salaries well in excess of the minimum. In fact, the existence of a datum line in the form of a minimum-salary scale for the average man in the grade would provide a means of ensuring this.

The present practice of "paying a man what he is worth" has proved to be far from satisfactory, as is shown by the big differences between salaries paid by different firms to men of similar qualifications and ability. The only way a man can establish his "worth" is by offering his services on the open market and applying for another post, and even this inefficient and wasteful procedure may be impracticable for the older engineer.

In industrial life minimum rates of pay have been established for most classes of workpeople, and it is surely high time that professional engineers were assured of a minimum career value in their profession. The Association of Scientific Workers propose a minimum salary of 400*l.* per annum, with annual increments of 26*l.*, to 700*l.* per annum, for a man possessed of the experience and/or qualifications making him eligible for corporate membership of his professional institution. Surely this is a reasonable claim?

Yours faithfully,

F. B. Cope, B.Sc. (Eng.), A.M.I.E.E.

1, Carlton-road,
Welling, Kent,
February 5, 1948.

TO THE EDITOR OF ENGINEERING.

SIR,—In the leading article entitled "Professional Salaries," published on page 110 of your issue of January 30, 1948, you make the following statement: "If professional engineers, as a body, are ever to be in a position to dictate salary rates, the necessary steps will have to be taken by some organisation other than the engineering institutions, and it does not appear that any such organisation is yet in existence."

A suitable organisation, however, is in existence. It is the Engineers' Guild, an association of professional engineers which seeks to ensure adequate remuneration and conditions of employment for its members. Furthermore, the Guild takes a much wider horizon for its outlook than the negotiation of salary scales. It aims to bring all chartered civil, mechanical and electrical engineers into one organisation so that they may the more efficiently bring their undoubted talents to bear upon problems of public affairs. With functions such as these it is suitably designed to fill the gap in the organisational structure of the profession which the senior Institutions, by reason of their Charter limitations, would otherwise leave open.

"The Guild as an Association of Professional Engineers" is the subject to be discussed at a meeting to be held at 6 p.m. on March 10 in the Caxton Hall. Sir Peirson Frank, past-president of the Institution of Civil Engineers, will be in the chair, and discussion will be opened from the platform by Mr. O. V. Bulleid, past-president of the Institution of Mechanical Engineers, Dr. P. Dunsheath, past-president of the Institution of Electrical Engineers, and Mr. A. S. Quartermaine, member of Council, the Institution of Civil Engineers. Discussion from the floor will follow, when the wide phrasing of the subject title should offer an excellent opportunity for surveying the present condition of the engineering profession, and for suggesting methods of reform. The meeting will be open to all chartered civil, mechanical and electrical engineers, and for those who are dissatisfied with the contemporary status of their profession, here is a chance to do something about it.

Yours faithfully,
J. H. W. TURNER,
Honorary Editor.

The Engineers' Guild,
28, Victoria-street,
Westminster, S.W.1.
February 7, 1948.

RESEARCH IN AUSTRALIA.

THE 20th annual report* to be published since the Council for Scientific and Industrial Research in Australia was established by the reorganisation, in 1926, of the previously existing Institute of Science and Industry, covers the year ended June 30, 1946, and is notable for a number of changes associated with the transition from war to peace. In some directions, exemplified by the preservation of food, the change is mainly a reversion to a peace-time research programme, as contrasted with war-time attention to dehydration and canning. Similarly, the investigation of agriculture is now able to concentrate on pasture and weed problems generally, and, in particular, the exploitation of the vast unproductive areas of the Northern Territory. In other directions, however, the organisation of research for war is being adapted to peaceful aims, such as the development of civil aviation operations by radiophysics, and the prosecution of soil surveys and research on building and foundation problems connected with large post-war schemes of land settlement by demobilised troops. Finally, there are certain directions in which important peace-time industrial projects have warranted the formation of new divisions of research, such as those devoted to building materials and flax, which have come into existence during the year under review. The striking growth in these subjects of investigatory work, previously undertaken on a small scale by existing divisions of the research organisation, is paralleled by the case of textiles, for which a new Division of Textile Research is at present in course of establishment. For some time, work on wool textiles will continue to be carried out by means already in being, but it is easy to foresee a considerable expansion of textile investigations conducted independently of, yet collaborating with, the animal and plant product research stations whose business is the raw materials of textile fabrics.

The present position in building-materials research is representative of many aspects of the transition from war to peace in a new branch of investigation. The interests of the building industry are being met by emphasis for the moment on applied research, intended to assist in assessing the properties of existing and new materials, and in developing improved products and processes. Work is in progress on terra-cotta and cement tiles, with special reference to their use for roofs of buildings, and the durability of their various properties in service. An extensive programme of research on concrete is planned to embrace methods of waterproofing concrete walls, of accelerating the rate of strength increase, of making light-weight concrete and measuring its qualities, and of developing high-strength concretes. In all these connections, the properties of Australian aggregates are of such potential importance as to justify the extensive survey of stone that is being undertaken. The surface treatment of concrete when used as a flooring material has called forth some rather caustic comments on pitch mastic compositions that are alleged to give satisfaction in England. Studies of building boards in panel form are in progress, attention being given to their merits in respect of thermal and acoustic insulation as well as of mechanical strength, durability and surface finish. Australian materials for building are likely to differ significantly from those available in England and America, and it is apparent that a big programme of work must be completed before all desirable data are accumulated for the Australian building industry. Quite rightly, therefore, major attention has been devoted so far to testing equipment and experimental apparatus. Under the former of these heads, a notable item on order is a 1,000,000-lb. universal mechanical testing machine. Slow-motion cinema photography is proposed for studying the dynamic behaviour of floors, while chambers for curing concrete under controlled conditions of temperature and humidity will also be of use for testing miscellaneous building materials and are being designed to cover ranges of operation suitable for Australian products and climatic conditions.

Building is also among many industries that have made pressing demands, since the end of the war, on the Forest Products division of research. Among investigations aimed at economy in the quantity of wood necessary for floors and walls, the experimental determination of permissible thicknesses less than those hitherto regarded as standard has been completed for jarrah and mountain ash, while other materials now being studied include radiata pine. Among prefabricated wall sections, two of unusual interest comprise pressed-steel studs and sheeting, and face sheets of plywood or asbestos cement on a hardwood grid. Various types of proprietary building boards, including calcite and masonite, are having their properties comprehensively investigated, while for larger structures long-time loading tests on wood columns, split-ring connectors and shear plate joints are in progress. As regards the more fundamental mechanical properties of wood, research is being carried out to appraise the effects of moisture content on impact strength, and of rate of loading on compression strength. In the former of these studies, variations in Izod value associated with the direction of the blow, relative to the radial and tangential dispositions of the wood in the original tree, amount in some species, for example, King William pine, to as much as 60 per cent., and an attempt is being made to explain the effects on the basis of the wood structure in the several types examined.

In a related field, work is in progress to examine, more closely than has yet been done, the capillary structure of hardwoods, and hence to obtain background knowledge against which to study the general wood-water relations and their specific effects in such directions as shrinkage, creep under load, thermal conductivity and other physical properties. Electrical resistance wire strain gauges are being used for panel shear tests of plywood, while dielectric heating has proved helpful for experimental work on edge-glued timber joints and determinations of heat distribution in solid timber during drying. In this last class of investigation, it is interesting to remark on the continued growth of kiln seasoning plants throughout the Commonwealth consequent upon the post-war demand for seasoned wood for housing, furniture and general joinery. The research staff have given valuable help to the trade in such directions as the conversion of outmoded kilns, the aerodynamic design of new timber-conditioning equipment, and the development of improved drying techniques and processes. Somewhat parallel studies have been made with a view to enhancing the efficiency and output of sawmills in the cypress pine areas of Queensland. Still another line ofinvestigation has been devoted to the utilisation of wood by-products, and some other cheap and plentiful organic materials, for building. Typical of such products are sawdust, wood-pulp, wood chips, flax tow and straw, used as basic fillers and bound into moulded shape by means of Portland cement, magnesite, gypsum, bituminous preparations, synthetic resins and the like. Floor slabs have been made of cement, sand and sawdust over a range of mixes, and methods of accelerating the setting and drying of the mixtures are under investigation.

Another branch of timber research, having an important bearing on engineering practice, is concerned with methods of preservation. The work ranges from the underwater protection of wooden ships' hulls to mould prevention and tropic proofing of packing crates, and includes as a major project the preservative treatment of railway sleepers. Many of the Australian eucalypt timbers have good inherent resistance to decay and termite attack, but the supply has fallen below normal maintenance requirements, and enhanced scarcity is foreseen if unification of railway gauges is proceeded with. Intensive research is consequently in hand to evaluate the effectiveness of various preservatives and methods of applying them, and to compare the durabilities in service of treated and untreated timbers. The work includes statistical surveys to determine the principal causes of service failure and the effects of climatic conditions, from which it is already apparent that, in the State of Victoria, mechanical failures due to splitting, spike "killing," rail cutting and surface breakdown are so numerous that the problem of preservative treatment entails the dual necessity of retarding mechanical failure as well as of conferring lasting protection against decay.

An additional difficulty is that normal methods for pressure impregnation with preservative agents do not give satisfactory penetration into eucalypt truewood. Research has consequently been necessary to determine the effects of pressure, temperature, viscosity and polarity of the preserving fluid, and has revealed that, at pressures around 1,000 lb. per square inch, satisfactory penetration of many eucalypts can be obtained. This new high-pressure technique is potentially very important for Australia, but its uncertain practicability and high cost have encouraged the consideration of water-soluble preservatives for green timber, with the main object of developing the best diffusion treatment as an alternative to high pressure. Among the effects studied is the boric-acid diffusion process for preserving timber against the Lyctus borer. Methods of treating green veneer, to ascertain whether Lyctus attack on plywood can be prevented by the addition of toxic chemicals to the glue, are also under investigation, and include tests to compare the diffusion rates of boric acid and sodium fluoride in the radial and tangential grain directions for a range of woods. The extent and economic importance of marine borer attack in Australian waters are also being studied; in which connection it is of general interest to mention that, during the excavation of the Captain Cook graving dock in Sydney, a tree in a relatively good state of preser-

* *Twentieth Annual Report of the Council for Scientific and Industrial Research for the Year Ended June 30, 1946.* Published by L. F. Johnston, Commonwealth Government Printer, Canberra. [Price 5*s.* 4*d.* (Australian), postage 5*d.*]

vation was discovered in Pleistocene strata, estimated to be from 15,000 to 20,000 years old. The wood, identified as belonging to the blood-wood group of eucalypts, showed no marked differences of chemical composition as compared with present-day blood-wood. Although the lignin and carbohydrate had been modified, it was not possible to decide whether the wood would have ultimately become coalified, petrified, or converted to some other fossilised form.

Some of the Forest Products Division's varied work on plywood bears on the design of aircraft structures, on which subject the Division of Aeronautics is conducting stability experiments on plywood panels, under compression forces at different angles to the direction of grain in the surface plies. The effects of stress concentrations, especially at holes, in the plywood skin on the tension side of wooden aircraft wings are also being studied with the grain of the outer veneers at 90 deg., 45 deg., and 0 deg. to the direction of loading. A notable feature of this work is that the effects of size of specimen are being systematically examined. During recent years, increasing evidence has been forthcoming that the useful life of aircraft structures is curtailed by impulsive gust loading. In conjunction with the Department of Civil Aviation and the Royal Australian Air Force, a number of aircraft operating in Australia are being fitted accordingly with instruments to record the occurrence frequency of high-velocity and low-velocity gusts. On the laboratory side, a hydraulically-controlled test rig automatically applies to a wing repeated loads between prescribed limits of positive loading at any frequency up to 5 cycles per minute. Wooden Mosquito wings have endured 3,000 cycles of loading between 25 and 75 per cent. of the designed ultimate load, with little effect on their ultimate static strength. For use in the fatigue testing of beams and wings, formulæ have been derived to give the vibrational characteristics of members of uniform cross-section having concentrated masses at various positions along the span. The motive is to induce predetermined bending moments, shear stresses and torques in wings during tests involving the application of rapidly alternating loads. Several interesting developments in the use of wire resistance strain gauges for experimental stress analysis include a torque-measuring arrangement specially devised to test the efficiency of a large mine-ventilating fan. Some measurements of temperatures inside aircraft wings under tropical conditions have revealed that the skin temperature may be as high as 85 deg. C., and that the wing fuel tanks may reach 40 deg. C. Although aero-engine cylinder temperatures are not markedly affected by ambient air, it is worth mentioning that tests of Al-fin cylinders, which have the barrel finning formed in an aluminium muff, gave mean barrel temperatures from 10 deg. to 20 deg. C. lower than those of conventional steel-finned cylinders. The barrel finning did not, however, affect the mean cylinder-head temperature.

The main, 9 ft. by 7 ft., wind tunnel of the Division of Aeronautics, has been used for a variety of work, much of which is for the benefit of aircraft manufacturers; for example, a wing-fuselage assembly of a Commonwealth Aircraft Corporation's C.A.15 fighter has been tested to determine the contributions to lift, drag and pitching moment, of the cockpit canopy, tailplane, fin and rudder. Design tests are also in progress on two versions of a three-seater civil machine with pusher airscrews, designed by the Department of Aircraft Production. An interesting development for stability experiments is a six-component strain-gauge balance which has been designed to fit inside the hollow fuselage of a complete aeroplane model. For a long-term investigation of the influence of turbulence on boundary layer, hot-wire anemometry has been improved in accuracy, but the low-turbulence tunnel is still subject to undesirable velocity fluctuations. A new variable-pressure high-speed wind tunnel for sonic-speed work and general gas-dynamics research is now in use, though, so far, no more than preliminary calibrations have been carried out, with special reference to the wide-angle expansions upstream of the contraction into the working section, which are a feature of this tunnel and permit a high contraction ratio without an excessive length of tunnel. Breakaway at the sudden expansion is prevented by high-resistance screens across the maximum section, which stabilise the flow and control the turbulence very satisfactorily. Aerodynamic force balances and equipment for Schlieren photography of shock waves are in course of development.

In the field of aero-engine research, a complete re-orientation of programmes has been brought about by the advent of the gas turbine, and work is projected on several different aspects in which developments appear promising. They include the effect of air turbulence on combustion and the possible use of brown coal or its derivatives; the improvement of fuel control systems; and the correlation between theory, design and performance of compressor and turbine blades. Two Rolls-Royce Welland engines have been acquired for experimental purposes, while a further two Derwent engines are on order for fuel and combustion investigations. Eventually, no doubt, when the complete plant becomes available, turbine research will predominate; but, meanwhile, a number of useful investigations on reciprocating engines remain to be completed. Among them is a study of piston-ring lubrication for which a single-cylinder R. 1340 engine has been modified and equipped with apparatus for measuring the changes in electrical conductivity of the oil film. Breakdown of the oil film permits direct metal-to-metal contact and leads to wear of the rings and the cylinder walls. Previously, this technique has been employed with small engines running slowly under rather artificial conditions; the present work extends the measurements into the operating range of aero-engine cylinders. Another interesting development is the E 39 rotary-valve engine, in which a recent modification of the valve-lubrication system has been successful in reducing oil consumption at low throttle. The original valve design has been modified to increase the port area, and has given improved volumetric efficiency with consequent power increase, particularly at high rotational speeds. Another type of valve suitable for multi-cylinder in-line engines has given results which, while slightly inferior to those of the original valve, are much better than those which are normally obtained with engines of the conventional poppet-valve type. A small twin-cylinder rotary-valve engine, suitable for driving a portable generator, has been designed by the Aeronautical Research staff for construction by the Royal Australian Air Force.

Among researches ancillary to aero-engines are some experiments on air filters to demonstrate the effect of geometrical configuration on pressure drop and cleaning efficiency, and hence to deduce the optimum design of filters. Another promising piece of work is an "air miles-per-gallon indicator"—an instrument to show fuel consumption in relation to distance flown. Two devices have been tried. One, which relies on diaphragms for the transmission of pressures determined, respectively, by fuel flow and air speed, has had to be abandoned because of the extreme difficulty of devising diaphragms with the required characteristics. The second, and more hopeful, design employs two metal capsules which deflect cantilever springs fitted with electric resistance strain gauges. One capsule is actuated by fuel flow, the other by air speed; and the electrical output of both gauges is fed into a ratio meter to read directly in miles per gallon. At the request of the Royal Australian Air Force, air consumption and carburation measurements have been carried out on the Rolls-Royce and Packard types of Merlin engines, so that the operating conditions for maximum range can be specified. A Merlin engine is also the subject of an investigation into the distribution of tetra-ethyl-lead anti-detonant among the cylinders. It appears that, although the effects of unequal distribution of fuel have been realised for some time, the anti-detonant is not distributed in the same proportions as the petrol; with the consequence that some cylinders may continue to knock while others are harmfully affected by excessive deposits of lead.

With particular reference to all-metal aircraft construction, valuable metallurgical studies are in progress to improve Australian aircraft steels. Among the latter is a silicon-aluminium killed steel which, susceptible to strain-ageing in the cold-drawn condition, has been satisfactorily improved by normalising at 860 deg. C. prior to cold-drawing, followed by stress-relieving at 620 deg. C. Spot-welding of aluminium alloys, and of mild steel coated with tin, zinc, nickel, chromium or cadmium, is under investigation, as also are the effects of brazing time, temperature and gap on the shear strength of copper brazed joints. As part of the latter work, microscopic examination of the brazed joints has disclosed a fine dispersion of an iron-rich phase in a matrix of copper-rich solid solution. The mechanical-strength tests have shown that joints brazed at 1,180 deg. C. exhibit consistently higher shear strengths than those brazed at 1,120 deg. C.; and that time of brazing has no distinct influence on shear strength, whereas, for joints having gaps within the range 0 in. to 0·008 in., those with smaller gaps have higher strengths than those with larger gaps. In addition to some interesting developments in the application of powder metallurgy to the production of sintered-bronze bearings for aircraft, useful research has been continued into the inhibition of corrosion in cooling systems employing ethylene glycol by additions of sulphonated gyro oil, which has been found to reduce corrosion but slightly to diminish cooling efficacy by depositing a film on the radiator elements. A more fundamental investigation, which was instrumental in explaining the effect of tri-ethanolamine phosphate in glycol, has not indicated why corrosion resistance should have occurred. The mechanism of corrosion and film formation in aluminium and its alloys is being studied, and the effect of film breakdown has been demonstrated by causing silica powder to impinge on an aluminium electrode under water. An observation, believed to be novel, is that corrosion of aluminium may take place by the mechanism of hydrogen evolution in neutral solutions, as opposed to the more usual type of differential aeration. It occurs immediately before a ruptured oxide film has had time to reform.

In association with a comprehensive determination of the fatigue properties of S.A.E. 4140 steel, with special reference to the influence of surface finish, three forms of apparatus are being constructed for appraising surface quality by taper sectioning followed by microscopic examination, electrical amplification of stylus movement, and optical interferometry. It is intended to polish fatigue specimens of steel and aluminium alloy by the electrolytic process. Preliminary trials have been promising, but objectionable pitting around inclusions has not yet been successfully overcome. The results of the fatigue tests will contribute, no doubt, to the merits of a handbook of steels suitable for automotive work, which is being prepared for the Institution of Automotive Engineers with the object of rationalising the range of steels used in the Australian automotive industry.

(To be continued.)

IMPROVED RAILWAY BOOKING OFFICES.—The Eastern Region of British Railways have opened two new booking offices, at Stratford and Maryland stations which are designed as "shops for selling railway tickets," and are more attractive to passengers and more comfortable for the staff. Westinghouse "Rapid Printing" ticket machines, and "Bellmatic" ticket rack units are conveniently disposed behind a large plate-glass window. The furniture is in light oak, the floor is laid with parquet blocks, and fluorescent lighting is provided.

POLHILL TUNNEL REPAIRS.—From Sunday, February 22, to Sunday, March 14, inclusive, the 1¼-mile Polhill tunnel on the Southern Region electric line north of Sevenoaks will be closed, except between 7.45 a.m. and 10.00 a.m. each day, when one of the two lines will be used by some of the intense morning traffic. The track formation in the middle of the tunnel has been waterlogged for some time, and it has been necessary to impose a speed restriction of 30 m.p.h. on the down line and 45 m.p.h. on the up line. The chief civil engineer's department will therefore renew the tracks, lay fresh ballast, and improve the drainage. Except in the middle section, the track will be relaid by a new machine which has been designed to handle pre-fabricated track in a tunnel. While repairs are in progress, most of the traffic will be diverted via Otford and Swanley, and many up trains from the South-East Coast have been temporarily retimed to start several minutes earlier, to ensure that, in spite of the slightly longer journey, they will continue to fit into the intense traffic around the London termini.

NOTES FROM SOUTH AMERICA.

DURING the greater part of 1947, there was a deluge of imports into Latin America from the United States, where rapid post-war recovery of industrial production (far outstripping that of Europe) and the release of shipping from war-time duties, enabled orders which had accumulated over many years to be delivered within a short space of time and sooner than had been expected. This great inflow of imports, however, resulted in considerable depletion of Latin America's dollar reserves, and soon led to the imposition of severe import restrictions in the leading republics. Undoubtedly, many of these countries were converting their current sterling balances into dollars with which to purchase capital equipment, etc., from the United States, but this was stopped in August when the British Treasury placed Argentina, Brazil and Uruguay in the Transferable Account area. With commendable promptitude, the British authorities are now negotiating with the three countries concerned for new bases for the rehabilitation of British export trade. British trade missions are already in Buenos Aires and Montevideo, and a third is to proceed to Brazil. A favourable result of the negotiations with Uruguay is expected shortly, and it is presumed that the Uruguayan Government will finance out of sterling balances the acquisition of the British-owned tramway and water concerns. Similarly, the talks in Rio de Janeiro will also include the future of British-owned railways and other public utilities, as well as the supply of British transport and industrial equipment.

The negotiations in Buenos Aires have been protracted and frequently interrupted. There is hard bargaining over the related questions of the supply of foodstuffs to Britain on the one hand, and, on the other, Britain allowing the conversion into dollars of part, at least, of Argentina's current sterling balances; this would enable Argentina to resume buying engineering, transport and other capital equipment in the United States for the Five-Year Plan. Argentina answers criticisms of high wheat and meat prices by pointing out the great increase in costs of urgently-needed imports, particularly manufactured steel and fuel. It is confidently believed, however, that a new Anglo-Argentine trade agreement will be arrived at shortly —to include payment for the British-owned railways— as it is vital that the uniquely reciprocal trade between the countries should be restored as soon as possible on an equitable basis. It is an encouraging augury that British coal shipments to Argentina have been resumed; before the war, such shipments were about 2,500,000 tons per annum and represented 25 per cent. by value of all Britain's exports to the River Plate.

It is indicative of Argentina's desire to foster industrialisation that the Government have appointed a special Commission to facilitate the entry into the country of industrial material, including machinery, as well as groups of skilled artisans, technicians and directive staff. Argentina's chief obstacle to widespread industrial development is the shortage of fuel and power; therefore, intensive efforts are being made to encourage local coal and oil production, and hydro-electric power, which should induce a demand for oil-drilling, mining and electrical equipment. A recent decree allocated the sum of 50 million pesos for the exploitation of the coal-mines in the basin of the Rio Turbio in South Patagonia, which were taken over recently by the State. A further decree approved an agreement between the Argentine State oilfields, known as Yacimientos Petroliferos Fiscales (Y.P.F.) and the Drilling and Exploration Company, Nevada, U.S.A., for drilling 40 exploratory oil-wells in Argentine at a cost of 50 million pesos, as part of the National Five-Year Plan. The Y.P.F. have announced the opening of a new oil-well at Barrancas, in the province of Mendoza; the output of the new well will be limited to 200,000 litres a day, to conserve the supply. Under a further decree, the Argentine Government has approved a proposal for the construction of three refineries by the Y.P.F., with capacities of 4,500, 1,500 and 1,000 cubic metres daily, in La Plasa, San Lorenzo and Luján de Cuyo, respectively; the contract has been awarded to the M.W. Kellogg Corporation.

One of the many schemes for hydro-electrification, the dam on the River Atuel at El Nihuil, Mendoza, was officially inaugurated on January 11. This dam was projected in 1907 and the work was started in 1939, but progress was interrupted by the shortage of materials during the war. The reservoir, when full will cover some 7,500 hectares (30 square miles) and have a capacity of about 260,000,000 cubic metres, making it the second largest in Argentina. Under the Five-Year Plan, it is proposed to build a 60,000-kW hydro-electric plant adjacent to the dam at an estimated cost of 40 million pesos, and eventually to erect a second plant of similar capacity. When these two schemes come to fruition, the electrical capacity in the province of Mendoza will be five times the present total of 24,000 kW. The Government intend to build several other hydro-electric stations along the Mendoza River, including one near Blanco Encalada, to cost nearly 11 million pesos and to be named Ingeniero José Antonio Alvarez Condarco.

Following many large orders for transport material abroad, Argentine imports of "machinery and vehicles" over the first nine months of 1947 (the latest figures available) rose from the 1946 figure of 83,800 tons (value 197,500,000 pesos) to 268,100 tons (value 803,800,000 pesos). Recent additional orders include Diesel omnibuses from the United States for the Buenos Aires City Transport Corporation, which proposes to make further large purchases of vehicles in that country as well as Italy. The Argentine State Railways have bought a large number of broad-gauge goods wagons from Canada, as well as electric locomotives from the United States, and are now building all-steel coaches in their own shops. Ships are being bought from the United States as well as from the United Kingdom. The Argentine Government have prepared plans for modernising the dredging equipment used for the approach channels of Buenos Aires, La Plata, Rosario, San Lorenzo and Santa Fe, and have authorised the purchase of several large dredgers from the United States and Europe at a cost of 105 million pesos. In addition, 40 million pesos will be spent on ten smaller dredgers and 25 million pesos on lighters and other equipment, making a total outlay of about 10,000,000*l.* sterling.

Brazil's transport and fuel problem continues acute, though some alleviation is indicated by the fact that, over the first nine months of 1947, imports of transport material cost about 36,000,000*l.* sterling against 14,000,000*l.* in the corresponding period of 1946, while imports of coal and coke increased by half a million tons. Undoubtedly, the present trade talks in Rio de Janeiro will deal prominently with the restoration of the valuable Brazilian market for British coal. The contract for the first Brazilian oil refinery in the State of Bahia has been awarded to the M.W. Kellogg Company of Delaware, and it is proposed to build another refinery at São Caetano near São Paulo, to deal with 20,000 barrels of crude oil daily.

The Brazilian Minister of Transport has stated that a sum amounting to about 1,500,000*l.* sterling has been earmarked for the re-equipment of the South Brazilian ports of Rio Grande do Sul, Porto Alegre, and Pelotas. A decree of June, 1947, approved plans for extending the Caju dock in Rio de Janeiro, and the first steel pile of the new extension was placed in position on January 20. It is expected that the work will be finished within a year. Following a demonstration of the British-made David Brown tractor in Brazil, negotiations are reported to be in progress for manufacturing them there. The National Motor Factory has been reorganised to produce tractors, vehicles, refrigerators, etc. Financial assistance from the Export-Import Bank of Washington is being used by the Cia. Vale do Rio Doce to proceed with their railway construction programme so as to facilitate supplies of iron-ore from the Itabira deposits to the steelworks at Volta Redonda. The latter concern has recently delivered in Rio de Janeiro the first consignment of benzol from their coke-oven plant, and benzol production for 1948 is estimated at 2,500,000 litres. The tank-cars used were built of steel from the Volta Redonda works. The manufacture of steel drums and welded steel tubes in Brazil is also being undertaken by subsidiaries of United States firms.

The Government of the prosperous republic of Colombia have drawn up many plans for ambitious and costly public works. These include the reconstruction of the Pacific port of Tumaco, recently destroyed by fire, the contract for which is to be placed with the Frederick Snare Corporation of Delaware. Large expenditure is planned on the construction of highways and adjacent airfields for emergency landings; irrigation and connecting up existing roads and railways; irrigation and hydro-electric developments; extensions to the docks and warehouses at Buenaventura; the construction of a coal dock by the National Railways, for which the contract has been placed with the Raymond Concrete Pile Company, of the United States; and the immediate enlargement of the Bogotá Waterworks.

A recent Colombian law provides that the Government shall undertake the commercial exploitation of the iron-ore deposits discovered several years ago at Paz del Rio, in the Department of Boyacá. Previous proposals received from American and Belgian concerns for this enterprise had been rejected, the terms offered having been regarded as onerous. This undertaking is to be of a semi-official nature, financed with both Colombian and foreign capital totalling some 100 million pesos. In addition, loans may be obtained, but those in foreign currency would be limited to the cost of equipment and materials required from abroad. The plans involve a considerable extension of the North Eastern Railway, as well as enlargement of the existing hydro-electric plant at Cusiana. It is understood that a mission will visit Mexico, the United States and Europe to study methods of operation, to obtain technical services and make financial arrangements.

RADIO COMMUNICATION ON MIDDLE EAST OIL PIPELINE.

A SYSTEM of radio communication, which will provide facilities for both speech and teleprinter operation, is to be established along the new pipeline that is projected between the Persian Gulf and the Mediterranean, a distance of some 800 miles. The necessary equipment for this purpose has been developed at the telephone and radio works of the General Electric Company, Limited, Coventry, in collaboration with the firm's research laboratories at Wembley. The consulting engineer for the scheme is Mr. Wilson Finding.

During the construction of the pipeline communication will be maintained between the base camps and the construction camps, over distances up to 150 miles; and between the construction camps and the working parties over distances of a few miles. Communication between the camps and travelling vehicles and aircraft will also be possible. Each camp will be provided with an amplitude-modulated high-frequency transmitter, which can be operated on two crystal-controlled frequencies. The receivers will be pre-tuned to these frequencies, one of which will be used during daytime and the other at night. The installation at the base camps will be of the semi-permanent type. That at the construction camps, however, will be mounted on a vehicle, which will carry a petrol-electric generator for supplying the transmitters and charging the batteries. A frequency-modulated very high frequency transmitter/receiver, with a transmitter output of about 20 watts, will also be housed on the vehicle. These units will be used to communicate with the working parties, who will be equipped with battery-operated pack sets with a transmitter output of 0·25 watt. In addition, there will be aircraft-type equipment, which will be operated from the vehicle battery. The transmitter of this equipment will be crystal-controlled and will have an output of 25 watts. The receivers will be tuned and locked on a pre-selected frequency. When practicable, the equipment will be sealed against dust and weather. In other cases it will be cooled by blowers.

When the construction of the pipeline has been completed, equipment similar to that at the base camps will be installed permanently at each pumping station. The terminal stations will be similarly equipped, except that the transmitters will be grid-modulated and will have an output of 1 kW on continuous wave and 250 watts on modulated continuous wave, or speech. It will be possible to select one of six crystal-controlled frequencies or a stable variable-frequency oscillator. In addition, each terminal and pumping station will have a 150-watt amplitude-modulated transmitter mainly for communicating with aircraft. This will have a frequency range of 300 to 600 kilocycles per second, with provision for three crystal-controlled frequencies or a variable-frequency oscillator. Receivers covering frequencies between 150 kilocycles and 33 megacycles per second will also be provided.

These facilities will give seven channels in each direction between each adjacent pairs of stations. Six of these will be used for speech and the seventh for a number of voice-frequency channels, which will be employed to give six teleprinter channels, and six dialling channels, as well as remote metering channels and spares. At every station there will be an automatic telephone exchange, some of the "subscribers" on which will be barred from using the trunk circuits, while others will be able to dial numbers both on their own and other exchanges. Some "subscribers" will also be able to break in on existing connections. It will be possible for the teleprinters at any station to be connected automatically to those at other stations and for the readings of certain meters associated with the pipe line to be displayed at all the stations.

Owing to the distance between the stations, intermediate repeater posts will be established at suitable sites, where self-supporting steel masts will be erected. These masts will carry aerials to give a gain of 12 to 15 decibels. Power at these stations will be supplied from Diesel-electric sets; and the equipment will be in duplicate, so that the spares can be brought into operation automatically in case the main apparatus fails. In principle, the repeaters installed will be high-gain amplifiers and frequency changers, with the control arranged so that crystal frequency drift will have little effect.

In addition to the very high frequency links, two "both way" speech circuits and two teleprinter circuits will be installed between the terminals. This service will be provided by two very high frequency links, each of which will carry one speech and one teleprinter channel, the former being operated from the automatic telephone exchanges at each end. The transmitters will have an output of 1 kW on speech; and will be capable of operation on six crystal-controlled switch-selected frequencies. The receivers will also be crystal-controlled and will be connected to highly directive aerials.

SPANISH COMMITTEE OF LLOYD'S REGISTER.

THE recent formation of a Spanish Committee of Lloyd's Register of Shipping constitutes another step forward in the international development of the Society. The new committee consists of the leading men in shipowning, shipbuilding and marine-engineering circles in Spain, and it will provide an effective means of placing the experience and knowledge of Lloyd's Register of Shipping at the disposal of the Spanish shipping community. The establishment of the committee will further strengthen the already strong ties between Spanish shipowning and shipbuilding circles and Lloyd's Register, and will lead to closer technical contacts which will be in the best interests of all concerned. The first chairman of the committee is Don Ernesto Anastagio, President of the Council of Administration of the Compania Trasmediterránea and of Union Naval de Levante, S.A., Madrid. The other members of the committee are Don Jesus Alfaro (vice chairman), vice-president of the Empresa Nacional "Elcano," Madrid; Don José Luis de Aznar, President of the Council of Administration of the Compania Naviera Aznar, S.A., Bilbao; Don Juan Antonio de Aznar, President of the Council of Administration of the Compania Euskalduna de Construccion y Reparacion de Buques, Bilbao; Don José Maria Cervera, director, Compania Trasatlantica, Madrid; Don Felix de Gregorio, managing director, Compania Arrendataria del Monopolio de Petroleos, S.A., Madrid; Don A. L. Grosso, director, Compania Maritima Frutera, Cadiz; Don Manuel Gubern, director general, Centro de Navieros Aseguradores, Barcelona; Don Luis Hermida, vice-president of the Comisariado Español Maritimo and director of La Union and El Fenix Español, Madrid; Don Augusto Miranda, director general, Societá Española de Construccion Naval, Madrid; Don Manuel Soto, director general, Union Naval de Levante, S.A., Madrid; and Don José Maria Ybarra, managing director, Ybarra y Compania S. en C., Seville. Sir Ronald Garrett, chairman of Lloyd's Register, and Mr. Colin Bartlett, O.B.E., B.Sc., deputy chief surveyor (administration) were present in Madrid at the inaugural meeting of the Spanish Committee.

LAUNCHES AND TRIAL TRIPS.

S.S. "VIKTUN."—Single-screw vessel, for the carriage of oil in bulk and other cargo. Built by Messrs. John Readhead and Sons, Limited. West Docks, South Shields, to the order of the Tanker Corporation, Panama City, the vessel is provided with a suite of rooms for the owner's use. Main dimensions: 405 ft. 10 in. by 60 ft. by 37 ft. 6 in.; deadweight capacity, about 8,000 tons on a draught of 24 ft., approximately. Fredriksstad double compound steam motor, built under licence by Messrs. John Readhead, with two Forster Wheeler water-tube boilers built by Messrs. Richardsons, Westgarth and Company, Limited, West Hartlepool, Wallsend-on-Tyne, giving a maximum speed of 13 knots. Launch, January 26.

M.S. "LABIOSA."—Single-screw tanker for the carriage of petroleum and bitumen in bulk; eight centre-line tanks, specially coiled, being provided for the latter. Built and engined by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn Shipbuilding Yard, Hebburn-on-Tyne, to the order of the Anglo-Saxon Petroleum Company, Limited, Great St. Helen's, London, E.C.3. Main dimensions: about 446 ft. by 54 ft. 3 in. by 31 ft. to upper deck; deadweight capacity, about 9,000 tons. Hawthorn-Werkspoor six-cylinder four-cycle engines, developing 2,700 brake horse-power and giving a speed of 12 knots fully loaded. Launch, January 26.

M.S. "FULHAM IX."—This single-screw vessel for the carriage of coal, specially designed for navigation on the River Thames, is the ninth of the series. Built by The Burntisland Shipbuilding Company, Limited, Burntisland, Fife, for the Fulham Borough Council, London, S.W.6. Main dimensions: 260 ft. by 39 ft. 6 in. by 18 ft. 9 in.; deadweight capacity, about 2,600 tons. Two-cycle Diesel engine of 1,520 brake horse-power, coupled to a double-helical single-reduction gearbox by an electric-magnetic slip coupling, constructed by British Polar Engines, Limited, Helen-street, Govan, Glasgow, and designed to give a speed in service in fair weather of 11½ knots. Launch, January 27.

S.S. "BRANKSOME."—Single-screw collier built by Messrs. S. P. Austin and Son, Limited, Wear Dock Yard, Sunderland, for Messrs. Stephenson Clarke Limited, 4, Fenchurch-avenue, London, E.C.3. Main dimensions: 243 ft. by 36 ft. 8 in. by 16 ft. 7 in.; deadweight capacity, 1,900 tons. Triple-expansion superheated-steam engines supplied and installed by Messrs. North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne, giving a service speed of 10½ knots. Trial trip, February 2.

LABOUR NOTES.

AT the time these notes are being prepared, it is difficult to estimate what the reaction of official trade unionists will eventually be to the parts of the Government's White Paper which directly affect them. The issue as it stands between the Cabinet and the Trades Union Congress General Council is clear enough, although, to describe it as simple would be to understate the gravity of the national economic position. There is, apparently, no serious difference of opinion regarding the value of collective bargaining on industrial questions. The T.U.C. believes in the system, and is strongly opposed to the idea of State-fixed wages. The White Paper says: "In the view of the Government, it is essential that there should be the strictest adherence to the terms of collective agreements. One of the main advantages of a system of collective bargaining is that it tends to ensure that wages and salary movements take place in an orderly manner, and with due regard to the general as distinct from the individual interests."

"Departure from the agreed conditions by individual employers, whether public authorities or private concerns," the Cabinet statement goes on to say, "will inevitably constitute a grave danger to the stability of the system of collective bargaining and may well lead to competitive bargaining and this to general but unjustifiable increases in wages and salaries and to serious inflation. The value of the system of collective bargaining, and the justification for its maintenance at the present time rest upon the assumption that the terms of collective agreements will be observed loyally by all employers and workers, and the Government cannot stress too highly the importance which they attach to this principle."

When it comes to the consideration of the various applications for wage increases which are pending, difficulties in respect of details emerge in the statement which cannot fail to embarrass both the Cabinet and the T.U.C. General Council. It is pointed out that the wage increases which are demanded, if conceded, would have disastrous results on the national economy, unless they were accompanied by a substantial increase in production. "It does not seem right," the statement proceeds, "to stabilise all incomes as they stand to-day. There may well be cases in which increases in wages or salaries would be justified from a national point of view—for example, where it is essential in the national interest to man up a particular undermanned industry, and it is clear that only an increase in wages will attract the necessary labour. It follows that each claim for an increase of wages or salaries must be considered on its national merits and not on the basis of maintaining a former relativity between different occupations and industries."

The Crisis Committee of the Trades Union Congress General Council considered the White Paper on Thursday last week. An official statement made at the end of the meeting said that "with the declared aim of the Government's policy to avoid inflation, the committee was in general agreement. But in view of the far-reaching implications involved, and the effects of the Government's statement upon the position of the unions and their wage negotiations, the committee came to the conclusion that consultation with the Prime Minister and his colleagues is necessary before the General Council can be in a position to give guidance to the affiliated unions."

It is stated in the January issue of the *Ministry of Labour Gazette* that the period of relative stability in wage rates, which began in mid-1946, continued until the middle of 1947, but, in the second half of the latter year, there were increases in some of the major industries. In the industries for which statistics are compiled by the Ministry of Labour and National Service, the increase up to the end of June was about 300,000*l.* a week, but, in the following six months, it was about 1,400,000*l.* a week. About 5,000,000 people shared the increases, and the general average was about 5 per cent. for the year, making it 73 per cent. higher than in September, 1939.

In many industries, also, the length of the working week was reduced without any decrease in weekly wage rates. This had the effect of increasing hourly rates, and it is estimated that the increase in hourly rates was between 9 and 10 per cent. on average, making a total increase since September, 1939, of about 84 to 85 per cent. These percentage increases do not, of course, take into account increases in average earnings from such causes as fuller employment, overtime working, and extension of payments by results.

Of the total increase of about 1,750,000*l.* a week, nearly two-thirds was accounted for by increases in agriculture, coal-mining, building, public works contracting, and in the railway service. The official figures for 1947 are smaller than in some recent years, because unions were still occupied in the early part of the year in negotiating the first widespread reduction in hours of labour since 1919-20. In 1947, 5,213,000 persons had an aggregate decrease of 18,396,000 hours a week. In 1946 and 1947 together, 7,341,000 employers had an aggregate decrease of 24,115,000 hours.

The Ministry reckons that there were 1,717 stoppages of work, due to industrial disputes in 1947, compared with 2,205 in 1946, but the number of persons involved went up from 526,000 to 619,000 and the number of working days lost from 2,160,000 to 2,430,000. In the first year of nationalisation, the coal-mining industry accounted for more than one-third of the aggregate number of working days lost in 1947. The number of stoppages in the industry fell from 1,329 to 1,049, but the number of persons involved rose from 216,600 to 307,500 and the number of days lost from 420,000 to 912,000. In transport, 627,000 days were lost compared with 162,000 in 1946; in shipbuilding, 324,000 compared with 194,000; and in engineering, 211,000 compared with 566,000.

In the House of Commons last week, Mr. W. T. Scott-Elliot, the Labour Member for Accrington, asked the Chancellor of the Exchequer whether he could give early consideration to the remuneration of the higher grade of the Civil Service. Sir Stafford Cripps replied that he had appointed a committee to advise Ministers as to the general level of remuneration of the higher posts of the Civil Service—administrative, professional, scientific, and technical—and on any particular principles involved. The members of the committee were, he added, Lord Chorley, Sir Frederick Bain, Mr. George Gibson, Sir Hector Hetherington and Lord Layton.

The Metal Trades Committee of the International Labour Organisation has adopted a resolution indicating the range of industries and trades with which it is concerned. It is declared that the term "metal trades" shall include the fabrication, manipulation, and construction of iron and steel and non-ferrous metals (but excluding precious metals), as well as their substitutes, both in manufacturing and processing; and in the repairing and servicing of finished or semi-finished products. It was agreed that it should be made clear that the metal industry as thus defined is not concerned with the production of non-ferrous metals.

In the course of a speech to the Ministry of Supply Joint Industrial Council, Mr. G. R. Strauss, the Minister of Supply, said that the Ministry's policy for the Royal Ordnance Factories could be put simply in this way:—"For their war potential as for their economic usefulness to the nation, we must keep the factories as active concerns with a healthy complement of workers. The permanent establishment of a proportion of workers is already under consideration. My purpose, therefore, will be to seek for these factories every kind of alternative work that they can profitably undertake." The Minister added that the present labour force of the factories was 39,600, and for the near future it was likely to continue at much the same level. That did not mean, he said, that there would be no fluctuation. Some factories would present their special difficulties, which could not be overcome at once, but over the factories, as a whole, he did not expect the total employment to vary as much as 10 per cent.

Latest official figures relating to coal-mining, indicate that absenteeism was up and output per man-shift down in the week ended January 24, compared with the previous week. In the week ended January 17, voluntary absenteeism among coal-face miners was 7·58 per cent., compared with 7·76 per cent. in the week ended January 24; in the week ended January 25, 1947, voluntary absenteeism among coal-face miners was 11 per cent. Output per man-shift at the coal face in the week ended January 24, 1948, was 287 tons, compared with 289 tons in the previous week and 282 tons in the week ended January 25, 1947.

Of 119 disputes leading to stoppages of work reported to the Ministry of Labour and National Service as having begun in December last, 12, directly involving 2,900 persons, arose out of demands for advances in wages; 54, directly involving 7,100 persons, arose out of other wage questions; 8, directly involving 1,500 persons, arose out of questions relating to working hours; 12, directly involving 1,600 persons, arose out of questions respecting the employment of particular classes or persons; 12, directly involving 2,900 persons, arose out of other questions concerning working arrangements; and 1, directly involving 200 persons, arose out of a question of trade union principles.

SHEFFIELD WATER WHEELS.

FIG. 1. TILT HAMMERS IN SHEFFIELD INDUSTRIAL MUSEUM.

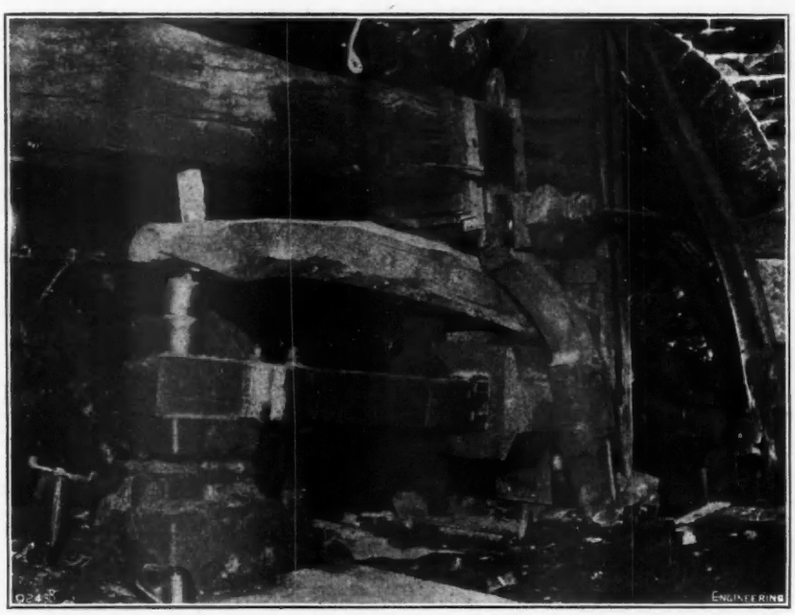


FIG. 2. TILT HAMMER AT WORTLEY.

THE WATER WHEELS OF SHEFFIELD.*

By ARCHIBALD ALLISON.

WITH the old water wheels of Sheffield is bound up the whole story of the growth of the social and industrial life of this great steel producing centre over the past 750 years. Water power has probably seen greater use in the river valleys of the Sheffield region than in any other part of Britain. Many of the large steel works, bearing names which are famous throughout the world of industry, have been built up from small beginnings round the picturesque but now disused dams that are such a pleasant feature of the five valleys which converge to form the main stream of the River Don. A leaflet written by an unknown author, and printed in 1794, gives a list of 111 water wheels and five "steam wheels" operating at that time. W. T. Miller's admirably comprehensive history of the Sheffield water mills, published in 1936, mentions 144 dams in an area ranging from Oughtibridge to Tinsley. Of these, visible traces now exist of not more than about 80. It should be remembered, however, that the number of dams does not give an accurate guide to the total number of water wheels, for it is known that one dam often worked more than one wheel at the same time, while there are many cases recorded of wheels being built to replace others which had fallen into disuse, the source of power in all these cases being one common dam. Perhaps still the best picture of the river scenes around Sheffield is given by Justice Fitzherbert, in his *Boke of Surveying* published in 1538, in which he says that "there be many manner of mills, corn mills, fulling mills, scythe mills, cutlers' mills, smith mills, and others as the wheel goeth by drift of water."

Information about the very early work of the water wheels is not as plentiful as could be wished, but from such sources as manorial court rolls, and sundry deeds, wills and settlements, evidence can be gathered which establishes that the earliest mills were employed for the grinding of corn, thus providing relief from the former laborious hand methods, and that there were three main centres in the region of Sheffield from which the knowledge of water power spread. The earliest water mill was built on the Blackburn Brook, a small stream between Sheffield and Rotherham, by the monks of Ecclesfield Priory in 1141. Some 20 years later, in 1160, the monks of Kirkstead Abbey, in Lincolnshire, established a grange near Kimberworth, under a charter which permitted them to mine and smelt iron. They put into operation a water mill on the same Blackburn Brook, but lower down the stream.

The year 1183 saw the foundation of Beauchief Abbey, at a point three miles to the south-west of Sheffield, by Robert Fitzranulph, who included in his gifts of lands his water mill at Norton. Sheffield was a chapelry under Ecclesfield until 1288, and it is recorded that in 1210, Lady Matilda Lovetot, the Lady of the Manor, charged the Town Mill at Lady's Bridge with one mark a year for the canons of Beauchief Abbey. In 1280, the Abbey also received from Sir Ralph de Ecclesall the gift of his mill on the Sheaf with sole milling rights, from which is derived the name of what is now the pleasant suburb of Millhouses; while the same donor gave land for a walk mill, or fulling mill, under the agreement that he was to pay one third of the costs and receive one third of the profits. This particular mill existed for 600 years until demolished to allow for the building of Dore Station. Beauchief Abbey ultimately possessed five mills, including an iron forge in what is still known as Smithy Wood.

From these three centres the practice of water milling expanded. In 1219, Gerard, Lord Furnival, willed one third of his mill at Bradfield, high up the River Loxley, to Worksop Priory. To the same Priory, in 1328, Thomas de Furnival paid five marks yearly for his mill at Brykeserth (Brightside); while, in the same year, it is said that the monks of Kimberworth were supplying iron to various forges at Attercliffe and Brightside. A frequently appearing name in the records about the time of 1329 is that of John de Walkmylne, who seems to have owned two fulling mills on the site where now stand the works of Messrs. T. W. Ward, Limited; while, in 1380, William, Lord Furnival, numbered among his possessions the mills at Ollerton (now Owlerton) and Wordesend (Wardsend).

Even in these early days, the water wheel was serving a variety of trades in addition to its original purpose of corn milling; the same wheel, in the course of its history, often served many different trades, a factor which goes far to explain the confusion which exists in a number of cases regarding the identity of an individual mill. A common practice was to change the name with a change of work. The trades that can be listed as depending on the power of the water wheel in those early years included silk milling, cotton milling and snuff making, in addition to the grinding mills for cutlery, files, scythes and other edged tools, and the wheels driving for the heavier iron trades such as tilting, forging, and slitting, and those employed for the walking or fulling of cloth.

In the old practice of cloth fulling, the walk mill superseded another laborious former method. After weaving, cloth required fulling, or making more compact, by beating or treading with the feet, from which comes the modern surname of Walker. Water power successfully supplanted the old foot method, in spite of strong objections that the cloth would not stand up to the mechanical beating of the water wheel.

The work of the mill wheel in such applications as textile manufacture is generally familiar; and the old corn mills, with two horizontally revolving grindstones driven from the water wheel through vertical shafts, are too well known to need detailed description. The different trades embraced by the making and working of iron and steel with the aid of water power, however, are not so well known outside the districts where the industry was carried on; and as, from the Fifteenth Century onward, the work of the local water mills was increasingly provided by the iron trade, a brief sketch may be given of its development and of some of the processes involved.

In 1442, William Rodes was granted the right to get iron ore and the fuel needed for smelting it from the Forest of Rivelin, on payment of 10*l.* per annum. The Chase of Rivelin, as it was called, was then a fine forest with splendid oaks, which were used, among other purposes, to furnish the axles for water wheels; and at the same period the area termed Sheffield Park contained enough underwood to serve two forges. In the following year, Rodes bought similar rights for the district of Hallamshire.

From early times until the Seventeenth Century, iron was extracted from the ore in a small charcoal fire, blown by either foot bellows or animal power, and producing about 14 lb. of what would now be

* Lecture delivered to the Society for the Preservation of Old Sheffield Tools. Abridged.

SHEFFIELD WATER WHEELS.

FIG. 3. REMAINS OF HAMMER AT MOUSEHOLE.

FIG. 4. CAM-OPERATED BLOWING ENGINE.

termed wrought iron for eight hours work. About 1450, on the Continent, and rather later here, large square stone furnaces were built and were supplied with a powerful blast from bellows worked by water power. The higher temperatures obtained with the stone furnace caused the iron to run out liquid, in the form of what is now called cast or pig iron, and, at first, no known method was capable of dealing with it. Eventually, it was discovered that this type of iron could be refined or softened by submitting the long pigs to a charcoal fire blown by something stronger than foot bellows, and for the source of power to provide this increased blast the iron smelters turned to water; hence the practice arose of siting the furnaces along water courses.

This process was known as the finery hearth, and produced wrought iron from pig iron. The larger quantities thus obtained were dealt with under tilt hammers operated by water wheels, which therefore provided both the blast for refining the iron and the power to hammer and work it. At a later period, some iron was rolled into sheets which were passed through slitting rolls and thus cut into small strips or rods of approximately square cross-section to form the raw material for hand-forged cutlery or for nail-making. This latter process alone would ensure constant work for the mills, for nails were an essential commodity. At this time, too, knives, or thwytels, were still made wholly of iron; a practice which continued until 1614, when the Cutlers' Company ordained that none should be made without any steel in them, the likely inference being that the edge should be of steel.

Of all the processes in the making of iron and steel to which water power was harnessed, none was more important than tilting. Tilt hammers could produce rough rods for use in wire drawing, but, until the Seventeenth Century, the greater part of their output consisted of bars in a variety of cross-sections, or heavier forgings such as anchors or anvils. The illustration (Fig. 1, page 165) of the tilt hammers at the Abbeydale Works gives a good idea of the type. The water wheel drove a large main shaft, in early days usually constructed of oak, on which were fixed bosses of large diameter, with cogs projecting from the periphery. When the shaft revolved, these cogs forced down the tail of the hammer shaft, or helve, which was pivoted at a point a little farther along its length. On the nose of the helve was fixed the hammer head, in the form of a shoe. When the tail of the helve was forced down the hammer head rose until the cog on the driving shaft became disengaged, when the hammer head fell freely on the forging, held by the tilter on the hammer block, fixed in the floor.

The hammer shown in Fig. 1 was employed mainly for scythe making, in which a very heavy blow was not required. For heavier work, however, such as was carried on at the famous old forges of Mousehole and Wortley, two expedients were employed to increase the power of the blow. In the first place, the height of the hammer block was lowered, so allowing a longer travel for the hammer head; and the second modification was the introduction of a large oak beam, fixed firmly above the hammer. Underneath this beam was located a strong wood spring, made in arc or crescent shape, which was lifted up by the helve, so adding force to the blow. Fig. 2, on page 165, showing the Wortley hammer—which is claimed to have forged round shot for Cromwell's army—illustrates the method of construction. Another difference between this type of hammer and the one at Abbeydale is that the helve was fixed parallel to the driving shaft and not at right angles, the cogs being applied at the nose and not at the tail.

In the Seventeenth Century, a further employment for the tilt was found. At this time, bars of iron were imported from Sweden, Norway and Russia, into Newcastle, and "cemented" into steel. This process entailed soaking the bar in a bed of charcoal at a temperature of 800 deg. to 1,000 deg. C. to permit carbon, in gaseous form, to permeate the iron and to change the outer layers of the bars into steel. These bars were then hammered down to a smaller size and became the raw material for all steel products at that time. In the later years of the same century, the cementation process spread to Sheffield and it was found that the water-driven tilt hammer could deal with this type of steel in a manner adequate for any required purpose.

From hammering the iron produced in fineries blown by bellows operated by the water wheel, and its later use on cemented steel, the tilt hammer progressed to the hammering of the crucible steel first produced by Huntsman in 1742. Still later, the tilting trade developed a fine proficiency in accurate work, and was eminently suitable for working quantities too small for the economical employment of rolling mills. Unfortunately, this latter merit has contributed considerably to the decline of the trade, because the tilter has always been paid on a piece-work tonnage rate, and the fact that he was so often employed on small-quantity work made his earnings less than his skill deserved. For this reason, the number of tilters who will now allow their sons to follow the family occupation is negligible, and the trade, which has so much to commend it for both skill and antiquity, seems doomed to an early extinction.

The development of water power for tilting and grinding kept pace with the demand from the forges. So many wheels were used for grinding in the Eighteenth Century as to confirm the view that, even then, Sheffield was the principal cutlery-making centre of the country. Records show that rents for wheels were higher, the lower they were situated down the river. The wheels lower down the river were more easily accessible from the town, but another reason for the higher rents was that the downstream mills would have more water due to the inflow of tributaries, plus the water from the dams higher up as they emptied, and could thus offer more regular work for the tenants

In the old grinding mills used on cutlery or edged-tool work, the grinding was done in "trows" or troughs, which carried the grinding, glazing, and buffing wheels, driven by a common belt from the main water wheel. In the case of cutlery grinding, for example, the same "trow" would serve three men. The grinder, with his heavier wheel, worked at the front of the trough; behind him would work the glazer, whose wheel was often of wood covered with leather on which was glued emery to remove grinding scratches; and, standing third at the trough, the buffer would give the final polish to the blade.

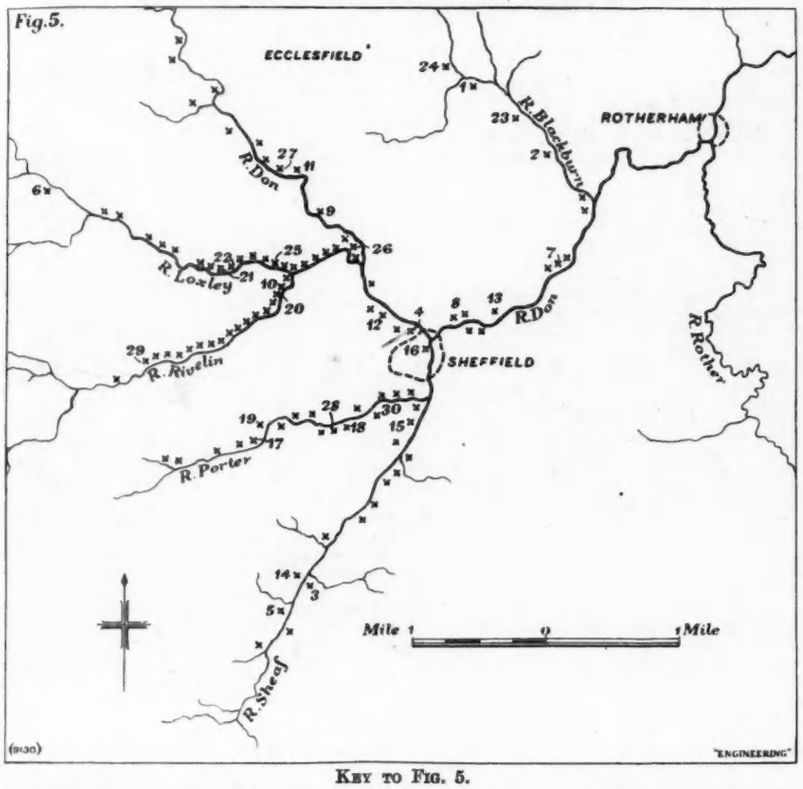
A point of interest occurs in the different approach to this type of grinding made by the old English, French and German grinders. The English practice consists of grinding at what is known as "12 o'clock" on the grindstone, that is, at the top of the wheel as it spins away from the operator; whereas the German grinder always worked at "3 o'clock," or at the front of the wheel as it spun downward. The French method was to lie flat above the wheel and grind at "9 o'clock" on the far side of the stone as it spun away. In this position, the grinders often complained that their legs and feet became cold, and the peculiar practice developed of training dogs to lie across the grinder's legs to keep them warm.

Another interesting feature of grinding practice is provided by the old file grinders, whose method of working was to sit athwart a board under which they held the file being applied to the wheel. In this way, the whole weight of the grinder's body was borne upon the file and thus the maximum pressure could be applied to the job. The board can still be seen in use in some of the older mills, a few of which still take their power from the water wheel, and is known by a name which, though modern fastidiousness of taste may consider it too strong for printing, describes its function perfectly.

For all these trades, and for others such as glass grinding, the water wheel was the main provider of power until well into the Nineteenth Century. It is also recorded that, at the Nether Mill on the Sheaf, the water wheel gave the draught for the furnace of a lead-melting cupola, the lead for which was brought by packhorse from the Derbyshire mines. Not least among the duties of water wheels was the provision of a strong air blast through bellows, for which it was employed from the days of ironmaking in the ancient bloomeries and on the finery hearths of the Fifteenth and Sixteenth Centuries; while, in the later process of heavy forging, blowers worked from the water wheel were in constant use.

In heavy forging work at the Mousehole Forge,

SHEFFIELD WATER WHEELS.



KEY TO FIG. 5.

1. Paper Mill, Blackburn Brook, on site of old mill founded in 1141.
2. Grange Mill, on site of mill founded in Kimberworth in 1160.
3. Beauchief Abbey (1183).
4. Town Mill (1210).
5. Dore station, the site of the Walk Mill built for Beauchief Abbey (1280).
6. Low Bradfield Corn Mill (1219).
7. Brykeserth (now the Brightside Forge) (1328).
8. Walk Mills (1329).
9. Wordesend (Wardsend) (1380).
10. Mousehole Forge (1600).
11. Clay Wheels (1700).
12. Upper Morton Wheel (1637).
13. Attercliffe Forge (1590).
14. Abbeydale Works Museum (1780).
15. Clough Wheels (1637).
16. Mill in the Poandes (1575).
17. Shepherd's Wheel (1584).
18. Snuff Mill (1700).
19. Ibbotsons Wheel (584).
20. Walkley Bank Tilt (1794).
21. Cliffe Wheel (1794).
22. Carr Wheel (1549).
23. Wragg Wheel (1552).
24. Whitley Mill (1552).
25. Wisewood Forge (1530).
26. Slack Wheel (1624).
27. Beeley Wood Works (1783).
28. Nether Lescar Wheel (1620).
29. Rivelin Corn Mill (1600).
30. Broomhall Wheels (1600).

Dates refer to the earliest authentic records of the respective wheels, but, in many cases, the wheels were working before the first written records were made. Each cross indicates the position of a water wheel, past or present. Only the wheels mentioned in the text are identified by numbers.

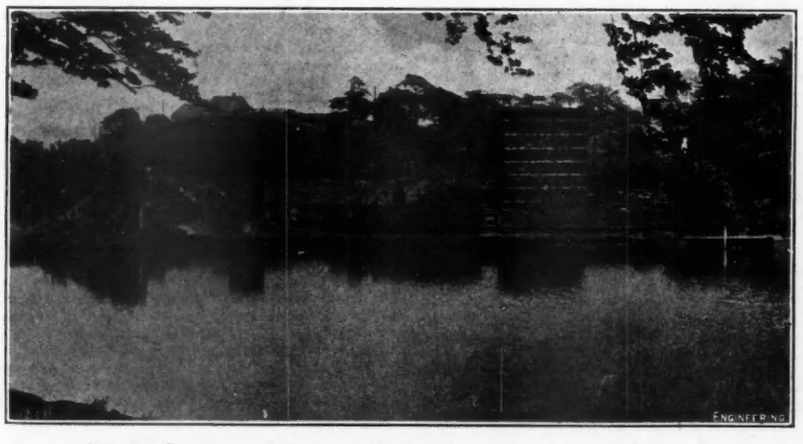


FIG. 6. SHEFFIELD INDUSTRIAL MUSEUM (FORMERLY SCYTHE FACTORY).

where the maximum water power was needed for the wheels driving the hammers, the forges and hearths were blown by blast conveyed through a 16-in. pipe from the neighbouring Grogram Wheels, 150 to 200 yards farther down stream. The normal practice was often to have a separate water wheel for driving the blowers, although usually this wheel worked from the same dam as the larger wheel driving the hammers. The common form of blower was apparently a square box with an inside plunger worked by the water-wheel shaft. In 1830, at Mousehole, there were four water wheels for hammer driving, and when these were working together they could lower the level of the dam two to three feet in two hours; although one wheel did work a bellows, it was necessary, therefore, to draw blast from Grogram to save water for the other wheels. In course of time, the provision of blast for Mousehole became the chief function of the larger wheel at Grogram. The remains of one of the Mousehole hammers are shown in Fig. 3, opposite; and the mechanism of a two cylinder blower in Fig. 4. The vertical wooden rods, actuated by the three-throw cams, are connected to the pistons in the two blowing cylinders, situated above the gear.

In the Eighteenth Century, most of the villages in the Sheffield area had cottage industries, the people carrying on such crafts as cutlery, nailmaking, and file cutting; the outbuildings can still be seen in which these home crafts were followed. That this fact was consequent upon the widespread growth of industry due to the extended use of the water power which was present in such abundance in the locality, there seems little doubt; and the continuous construction of dams and wheels which went on during the Sixteenth and Seventeenth Centuries would provide opportunity for a steadily increasing number of people to engage in these crafts.

The accompanying map of the five rivers, Fig. 5, with the mills and wheels marked, indicates the widespread use of the water wheel in the Sheffield district. Of the water wheels on the upper stream of the Don, one of the most interesting installations is that known as Clay Wheels, which is still in operation and is one of the last of the local forges to use water power These wheels were founded by the Clay family of Bridge-Houses, who were well known in the district from 1700 onwards, and it is said that the first wrought cannon to be made in Sheffield were forged on this site. Below Clay Wheels is Niagara Weir, from which runs a long mill goit which must be of very great age, for it is known to have served the ancient furnaces and forges of the Earls of Shrewsbury which were active from 1500 to 1600. Farther down again is the Wardsend Steel Works, on the site of the previously mentioned wheel which was old and ruinous in 1383.

Mentioned in the survey made in 1637 by Harrison for the Earl of Arundel, is Upper Morton Wheel, of which it is recorded that four persons paid 7*l.* 10*s.* 0*d.* per annum for "one halfe" and three others a similar amount for the other "halfe." At the Court-Leet held on April 30, 1723, the jury of the Sheffield "Soake" laid a pain upon one Daniel Hawley . . . "that unless he make a sufficient ffence to ye close between Morton Wheel and the Broadwater before the fifteenth day of May next, he shall forfeit and pay to the Lord of ye Manor 01-19-11," a fine of somewhat peculiar amount. The maximum fine that the Court-Leet could impose was 2*l.*

On the stretch of the river below Lady's Bridge, the Attercliffe Slitting Mill and the Attercliffe Forge were almost certainly built by the Earls of Shrewsbury, who operated them under their direct control until the early part of the Seventeenth Century. In 1590, both mills were apparently worked as forges, being referred to as the Upper and Nether Hammers, but, towards the middle of the Eighteenth Century, when the practice of rolling was developed, the upper hammer was changed to a slitting mill. One of the old wheels on the Don which is still being worked is at the Beeley Wood Works, where steel rolling is still carried on.

One of the most interesting of all the works in the Sheffield area driven by water power is the Abbeydale Works, on the Sheaf, which may well date back to the flourishing times of the neighbouring Abbey of Beauchief, although the first direct reference to it is in 1780. The unusual feature of Abbeydale was that the works were completely self-contained. The principal employment of the works was scythe making, and it possessed the entire plant necessary for such manufacture, from the crucible-steel melting furnaces and the forges to the grinding wheels, the storage sheds, and all the small associated workshops for this trade. Abbeydale suffered severely in the "rattening" outrages of 1842, the wheel being blown up with gunpowder.

Clough Wheels are included in Harrison's survey of 1637, and, in 1695, the Duke of Norfolk leased to . . . "William Turner of Sheffeild, sheeresmith, a cutlers wheele called Clough Wheele"; while, in the records of 1783, Samuel Norris had 40 "trows" here. In 1834, the grinding hull, containing eight edge-tool troughs, was operated by a water wheel 14 ft. in diameter by 7 ft. 10 in. wide, and the forge, with its one forge hammer and two tilt hammers, drew its power from a wheel 10 ft. in diameter and 8 ft. wide; but, apparently, there was only sufficient power to run one forge hammer and one tilt at the same time. Of the other wheels on the Sheaf, Pond Mill and Pond Forge were served by two dams running into each other, one of which must have worked the very old "Mill in the Poandes," the second of the original corn mills attached to Sheffield Castle.

The last of the grinding wheels on the Porter to remain in operation is Shepherd Wheel, originally

known as Porter Wheel and sometimes as 5th Endcliffe from its location in the Endcliffe Woods; it was known to be in work before 1584. At Whiteley Wood Rolling Mill, Thomas Bolsover, who built it in 1769, rolled the famous Sheffield Plate, drawing power from a water-wheel of the extraordinary diameter of 34 ft.; while Samuel Fox, the founder of the well-known firm that bears his name, worked at the Nether Lescar Wheel as a wire-drawer for Cocker Brothers about 1836.

The Snuff Mill, previously owned as a grinding wheel by the Duke of Norfolk, has been a snuff mill in the possession of the Wilson family since at least 1794, and is the only surviving wheel still working on the Porter below Hunter's Bar. In 1587, Ibbotson Wheel had already many years of service to its credit, while the Broomhall Wheels and Corn Mill existed in 1600, using two water wheels.

Apart from the Rivelin Corn Mill, the Earls of Shrewsbury possessed five cutlers' wheels on the Rivelin before 1600. This river has many mills of interest, including several engaged on the old and important trade of iron-fender grinding; one of these was the Rivelin Bridge Wheel, where cutlery and glass grinding was also carried on.

Walkley Bank Tilt used three tail hammers, one fast-working tilt hammer, a belly helve for iron work, and a wooden clay hammer which was employed to powder clay for coating bars to prevent scaling. In tilting cemented bars, making single or double shear steel, or welding iron into steel, it was important to shield the metal from oxidisation and loss of carbon. By plunging the bar when hot into powdered clay, a layer of protective slag was formed. The main beam at Walkley Bank, of square cast iron, once broke off short, and when the new beam was on its way to the tilt many doubts were expressed as to the ability of the bridge at the end of Mousehole Lane to carry the weight of the 40-ton beam and the 20 or 30 horses needed to pull it. The bridge, however, successfully survived the test.

Mention has already been made of the famous Mousehole Forge and the near-by Grogram Wheels. The origin of Mousehole is unknown, but evidence exists to show that forging was already an accepted practice here before 1637; and, from the fact that pig iron in bulk was supplied here from Emley and Rockley in 1728, it would seem that refining into wrought iron was also carried on there. One speciality of the works was the making of anvils and vices, for which heavier hammers were necessary.

The works on the Loxley cannot be mentioned without bringing to mind the disastrous Sheffield flood of 1864, when the Dale Dyke reservoir burst and brought devastation to the valley. The year 1864 is a sharp dividing line across the history of this area, not least in the minds of local people, many of whose ancestors were drowned and very many more rendered homeless. The mill of which, in 1219, Gerard, Lord Furnival, gave one-third to Worksop Priory, and of which Thomas de Furnival was said to be "seised" in 1337, was later known as Low Bradfield Corn Mill. It had a continuous working existence from those times until 1864, when it crumpled beneath the first rush of the flood waters, and, like so many other water wheels on the same stream, was demolished. After the flood, the dam which served Cliff, or Upper Cliff, Wheel, was merged with that supplying the works at Little Matlock, which had been completely swept away and where a rolling mill was built in 1882 which is still driven by water power.

The age of Carr Wheel has now been established with certainty by an interesting document recently transcribed from the Beauchief Muniments in the Sheffield Central Library by the archivist, Miss M. Walton. This document quotes an indenture, made in 1549, relating to the construction of this wheel, which was then known as Ashingcar Wheel. The cost of construction was 7*l*.

Another document in the Sheffield Reference Library, a grant dated 1530–1, refers to the dams at Wisewood Forge as "A messuage and a wheel called the North Wheile at Wysewode abutting on a water called Locksley on the South .... and a wheel called the Hont Whele on the West." At Malin Bridge, where the corn mill still works by water wheel, there stood a grinding wheel which, in 1794, worked twelve "trows"; while, farther down the river, may be seen the common goit for Upper Slack Steel Works and Nether Slack Tilt. "Slack Wheel near Ollerton" is mentioned in a rent book of the Manor of Sheffield of 1624, and, in 1718, the rent of a .... "Double Wheele House near the Slack House Farm" was 8*l*. per annum, paid by Mr. George Bamforth of High House, the Lord of the Manor of Owlerton of that time.

Although hardly of considerable size, the Blackburn Brook claims special mention in any story of the water power of Sheffield by reason of the undoubted antiquity of the first installations upon it. The water mills built by the monks of Ecclesfield Priory and Kirkstead Abbey in 1141 and 1160, respectively, and which were later known as the Paper Mill and Grange Mill, have already been established as being two of the original points from which the use of water power spread. In 1451, the Paper Mill was listed as belonging to the priory and convent of St. Anne of Coventry, when it probably ground corn; and on this same site, in 1794, flourished a cotton mill, which later turned to paper making.

The Upper and Nether Corn Mills are not easily identified, but in rent rolls of 1600 onwards these names appear frequently. The Oliver or Wragg Wheel is believed to be the "wheele under Eggleafeld" in the will made in 1552 by one John Parker, a scythesmith, who is known also to have used the wheel at Whitley Mill, where he had a smithy. In 1617, at a court of Sheffield, Francis Parker of Whitley, Gentleman, granted .... "one water mill and one kiln in Whitley" to Thomas Parkyn of Mortomley, Yeoman, on payment of one penny "when lawfully demanded." This is the same wheel.

Blackburn Wheel seems to have been used largely for the grinding of forks, containing ten "trows" for this purpose in 1794, and appears to have continued at this work until about 1880, when it was converted into a different type of grinding mill which was employed for the preparation of foundry blacking. The works finally closed down in 1909. The Blackburn Brook can therefore claim an unbroken use of the water wheel extending over more than 750 years.

It is a melancholy fact that the disappearance of so many of the older of the water mills of the Sheffield region has been occasioned not only by the passage of time, but also by neglect. These old mills were an important and highly interesting bridge between old hand methods and the modern use of mechanical power, and it is more than unfortunate that a story of such instructive and antiquarian interest should be rendered incomplete by neglect such as that suffered by the famous Mousehole Hammer, for example, which now lies in the deplorable state shown by the illustration, Fig. 3, on page 166.

It is gratifying, therefore, to remember the good work done by the Society for the Preservation of Old Sheffield Tools, who have been instrumental in saving a number of old installations for the interest of posterity. The Society intend to preserve the fine old hammers of Mousehole and to re-erect them in the Abbeydale Industrial Museum, which is another of their more interesting ventures. This museum, shown in Fig. 6, on page 167, is the same ancient Abbeydale Works on the Sheaf which has been referred to above, and itself has the great interest of being an excellent example of a self-contained works. No more suitable choice could have been made for an industrial museum, and many notable pieces of old equipment are preserved here in surroundings entirely fitted to the purpose. Without the addition of the hammers from Mousehole, Abbeydale already possesses a set of five metal tilt hammers, two scythe tilt hammers and four water wheels.

The idea of turning these old mills into museums has also been applied by the same Society in the case of Shepherd Wheel on the Porter, the old mill that was willed by "William Beighton of Stumper Lawe, cutler" to his three sons in 1584, and is still in working order. Much old grinding tackle and equipment is being preserved here. In addition, the Society have not yet ceased their efforts to obtain for preservation the fine hammers of the Wortley Forge.

It is possible now to say with certainty that the progressive development of water power to a point where each of the five rivers was utilised to the maximum was the main foundation upon which Sheffield industry was built up, this extensive power enabling the expansion of different trades at a pace which could not be equalled in London and other places less favoured in this respect. The workers at these trades had no easy life, for the days of water shortage when the wheel was idle were many, and earnings fluctuated widely. Piece-work was the accepted basis of payment, and developed a sturdy independence. The men were free to work for whom they liked, and as and when they pleased. Much of the work was unhealthy and silicosis, or "grinders' asthma," took a terrible toll of their lives, especially when they were transferred to the "steam wheels" of Sheffield. Their craftsmanship earned them a wide-world reputation for high-quality cutlery and, as late as the beginning of this century, these independent workers maintained three packs of hounds. Every Monday was "St. Monday," when the hounds were put to the scent. To these pioneers in the harnessing of water power Sheffield owes a great debt.

ROYAL SANITARY INSTITUTE.—The Council of the Royal Sanitary Institute, 90, Buckingham Palace-road, London, S.W.1, have issued particulars of their prize essay competitions for 1948. Two prizes are offered, namely, the John Edward Worth Prize of 40*l*., for an essay on "Practical Improvements of Appliances or Inventions in or about Dwelling Houses," and the John S. Owens Prize of 15*l*., for an essay on "Atmospheric Pollution."

NOTES ON NEW BOOKS.

A Manual of Time and Motion Study. By JOHN W. HENDRY. Second edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, London, W.C.2. [Price 12*s*. 6*d*. net.]

MR. HENDRY'S excellent all-round survey of this subject has required no material alteration or addition for the second edition, but in his preface to it he has rightly stressed the increasing importance of time and motion study in a time of rising prices and rising wage claims. The book has the merit that it shows how output per man-hour can be increased without stressing unduly any one aspect of the subject. The application of incentives and methods of assessing a fair day's work take their place alongside the elimination of wasteful organisation systems and the efficient use of lighting and transport. He deals thoroughly with the basic methods of time study, the training of staff and the provision of equipment, without pushing the theory of its application too far. The book is to be commended for general use, therefore, as it is not likely to mislead the non-expert who has no background knowledge of the controversies and pitfalls that characterise the subject

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Bacon's Commercial Engineering. By JAMES BACON, M.B.E., A.M.I.C.E. Second edition. Crosby Lockwood and Son, Limited, 20, Tudor-street, London, E.C.4. [Price 7*s*. 6*d*. net.]

DESPITE a few shortcomings (notably, the lack of an index) to which we drew attention in reviewing the first edition of this book rather more than 13 years ago, it remains one of the best of the smaller manuals written for the engineer who requires to have some understanding of commercial affairs without having to accept direct responsibility for them. It is well summed up, in a foreword, by Mr. F. C. Hooper, who was until recently Director of Business Training in the Ministry of Labour and National Service, as one which "presents to the man training as an engineer the general setting within which a business is conducted and thus helps him to see his future business as a whole." It may be strongly commended (as the author also offers it) to candidates who are preparing for Section C of the associate-membership examination of the Institution of Mechanical Engineers.

Industrial Electrical Motors. Second Edition. Issued by Messrs. Higgs Motors, Limited, Witton, Birmingham. [Price 1*s*.]

THIS handy pocket brochure of some hundred pages is being issued for the general guidance of electricians and others responsible for the transport, installation, and maintenance of alternating- and direct-current motors. Emphasis is laid on the low horse-power mass-produced or standardised type of machine. Some extracts from relevant British Standard specifications are quoted, together with tables such as those showing full-load line currents for motors of different horse-powers and voltages, and recommended minimum pulley diameters. Questions of earthing and motor starting are also discussed. Some reproductions of photographs show methods of handling when ordinary lifting tackle is not available, and ways of fitting and aligning pulleys. These, together with the basic circuit-diagrams and the section on trouble tracing, should prove especially helpful.

Algebra. By DR. A. PAGE. University of London Press, Limited, Little Paul's House, Warwick-square, London, E.C.4. [Price 18*s*. net.]

STARTING with progressions and going as far as determinants, this book provides a sound and satisfactory course of study for students who have obtained the School Certificate and wish to proceed to more advanced work. The author rightly considers that, at this stage of their mathematical education, it is essential for most students to understand how the subject is related to their various other interests, and has made this sufficiently clear by the inclusion of numerous examples illustrating practical applications to physics, chemistry, engineering, economics and medical science. There is also a chapter on the increasingly important subject of statistics. With topics covering so wide a field, however, some students may experience difficulty unless further explanation be forthcoming, and the utility of the book from a practical point of view must depend to some extent upon the versatility of the teacher. Numerous examples of a theoretical and practical nature follow each chapter and there are three sets of good revision papers, with answers. The book satisfies the requirements of students preparing for Higher School Certificate and university entrance examinations, and its practical character also makes it particularly suitable for use in technical schools.